Journal of

The Trail Boss ®

American Society of Range Management

The American Society of Range Management was created in 1947 to advance the science and art of grazing land management, to promote progress in conservation and sustained use of forage, soil and water resources, to stimulate discussion and understanding of range and pasture problems, to provide a medium for the exchange of ideas and facts among members and with allied scientists, and to encourage professional improvement of members.

Membership: Persons shall be eligible for membership who are interested in or engaged in practicing range or pasture management or animal husbandry; administering grazing lands; or teaching, or conducting research, or engaged in extension activities in range or pasture management or related subjects.

JOURNAL OF RANGE MANAGEMENT

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IN THIS ISSUE

Cover Photo—Cooperative Sagebrush Control in Harney County, Oregon

See Management Note by Dillard H. Gates, page 307.

This was mesquite, catclaw and oak– 15 acres would support one cow

Leo Jasik is a well-known Beefmaster breeder near Pleasanton, Texas. His land includes 516 acres of rolling, sandy range which, prior to 1964, could support only one cow to 15 acres. Now, a cow and a calf can be sustained on only 2½ acres of this same range. Where *one* cow grazed before, *six* cows and their calves graze today.

Leo Jasik brought this about through mechanical brush control and plantings of Coastal Bermuda grass in an area where the annual rainfall averages only 26 inches.

The program began in March, 1964, when 120 acres of mesquite, catclaw and oak were chained and rootplowed. Brush was stacked and burned, the land smoothed with a drag, then sprigged to Coastal Bermuda. By late June, Leo Jasik was able to put 77 cows on the new 120-acre pasture.

This same stocking rate has since been maintained, even throughout the winter months. During the dormant period for the coastal, supplemental feeding was done at the daily rate of two pounds of protein per cow. His 90% calf crop has increased to 98%, and his calves are averaging 100 pounds heavier than on the native range. His cattle are in excellent condition, and the Coastal Bermuda is now about 8 inches high, thick and spreading.

Jasik expects the entire improvement cost for this pasture—and the remainder of the 516 acres which was treated in 1965—to be paid off within three years!

Beefmaster cattle, and the advantages of Coastal Bermuda played parts in Leo Jasik's program. But the first step was mechanical brush control.

Mechanical brush control can be an important factor in your range reclamation program, too. Investigate by contacting a local conservation contractor or your Caterpillar Dealer. They can suggest methods best suited to your problem acres, discuss costs and returns.

CATERPILLAR

Journal of
RANGE MANAGEMENT

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Ranch and Range Economics

Grazing fees have been the subject of much interest and discussion—and some research—since 1961 (and periodically before that, of course). In 1963; after extensive study, public discussion, and formal hearings; the Secretary of the Interior revised and increased grazing fees collected by the Bureau of Land Management. Later a further increase in BLM fees was proposed to become effective in the spring of 1965; however, action has been postponed until the spring of 1967.

The American Society of Range Management includes members with a wide diversity of interests and opinions on grazing fee policy issues. It is hoped that our presentation of the following three articles will be informative, interesting, and stimulating to most of our readers.

The next three articles are based on papers presented in the Range and Ranch Economics Session of the Society's 1966 Annual Meeting at New Orleans, Louisiana. Dr. Charles J. Zwick's, an Assistant Director of the Bureau of the Budget, describes and discusses the Government's policy on user charges in general, and grazing fees as one of the many user charges. Professor W. Gordon Kearl, economist at the University of Wyoming, presents a critique of Zwick's address, and raises important questions about attempts to apply basic government policy to grazing fees. Dr. William E. Martin, economist at the University of Arizona, presents the results of recent research on ranch values and poses some important questions about our traditional approaches to ranch values and grazing fees.—*Russell D. Lloyd,* Member, Editorial Board, Journal of Range Management, Fort Collins, Colorado.

Fees and Charges as Tools of Public Policy[1]

CHARLES J. ZWICK

Assistant Director, Bureau of the Budget, Executive Office of the President, Washington, D. C.

Highlight

This paper describes the U.S. Government's policy on user charges. The basic rationale for this policy is considered, and questions are raised concerning the implementation of this policy in the grazing fee area.

Fees and user charges are important tools of public policy. They have a long history and promise to be with us for the indefinite future.

Although there is a firm and fixed policy on the role of user charges, the implementation of this policy in specific situations is far from fixed. Broad policy must, of course, be translated into specific fees or schedules of fees, and these must be adjusted in light of changing circumstances. If this translation from broad policy is to be done effectively, discussion is needed among the several interested groups.

My objective is to describe Government policy with regard to user charges, and to raise questions concerning the implementation of this policy in the particular situation of grazing fees. I hope to demonstrate the need for change. I also hope to obtain from you information which will help me discharge my responsibilities as an Assistant Director of the Bureau of the Budget. The Budget Bureau is responsible not only for advising the President on how to expend Federal resources, but also for helping him to assemble the information upon which to base his legislative program and his administrative action.

There is a long-standing Government policy on user charges, but I will concentrate on its recent history. After World War II, it was evident that many charges for special Government services were badly in need of being increased to reflect price changes. President Truman's Budget Message of January 1947 stated, "While it is not sound public policy to charge for all services of the Federal Government on a full cost basis, and many services should be provided free, the Government should receive adequate compensation for certain services primarily of direct benefit to limited groups."

During the next few years, several special studies were made which considered various aspects of user charges and the problem of applying them to such areas as transportation, recreation, agriculture, water resources, and the activities of regulatory agencies.

[1] *Address presented at the Nineteenth Annual Meeting, American Society of Range Management, New Orleans, Louisiana. February 3, 1966.*

In the Independent Offices Act of 1952, Congress set forth principles which guide us in these matters. President Eisenhower sent the first fully-developed package of transportation user charges to Congress.

To bring us up to date, in his Budget Message of January 1966, President Johnson stated, "The nature of many Government services is such that they should be provided without any charge or with only nominal charge. However, in certain cases, when a Government program provides special benefits or privileges to specific, identifiable individuals or businesses, appropriate user charges should be initiated. To this end, legislation will be proposed when necessary, and equitable user charges will be instituted administratively where authority exists to do so."

From this brief review, it is clear that the Government does have a consistent, repeatedly stated policy on user charges. For those interested in the details of this policy, it is formally documented in Bureau of the Budget Circular A-25.

Now let us consider the Government's record in applying this policy. There are today more than 1500 user charges in effect. In the three fiscal years 1963 through 1965, the Government adopted 155 new user charges and increased 415 others. During the same period, 86 user charges were decreased where costs or value factors called for such action. Change does not always mean an increase.

One year ago the President requested 52 agencies to report on their current efforts to extend the application of the Administration's policy on user charges. As a result of that action, the Administration initiated a number of proposals for new or increased fees. Legislation is now pending in Congress on a number of user charges. The President also intends to submit additional legislation for new fees during this session of Congress.

In terms of revenue implications, the most important set of user charges now awaiting legislative action are those in the general area of transportation, including highway, air and inland waterway user charges. To give you a feel for the breadth of the proposals now pending in Congress, I will cite several other areas: we propose to apply fees for meat and poultry plant inspection, fees for navigation services, fees for certain customs inspection services, and fees for inspection of towing vessels. A number of other examples could be cited but it is clear that we currently have a wide variety of user charges in effect and are diligently implementing Government policy in this area.

Viewed as a source of revenue to the Federal Government, the following picture emerges: User charges currently in force will yield approximately $1.5 billion in Federal revenue in fiscal year 1967. We propose to obtain additional revenue of $365 million in that year through the application of new user charges and increases in existing fees. By far the most important source of additional revenues from user charges will be the new transportation fees.

In summary, my major points so far are: first, we have a clear policy with regard to user fees which has been in effect for a number of years; second, this policy is broadly applied—we have over 1500 applications of the policy; third, it is an important source of revenues—based on current projects, a little less than $2 billion of revenue will result from these charges in the fiscal year 1967; and finally, the Administration is hard at work broadening the application of this policy to new areas and adjusting its application in others.

Now about the question of justification: Is it true that the only reason the Administration has a policy of instituting user charges is that it is a convenient way to add to Federal revenues? Or is it because of a pragmatic view that we can avoid pressures from special interest groups for new and bigger programs if we transfer the cost of those programs to the groups themselves? Budget makers might be tempted to advance that view; I doubt whether any President of the United States would adopt any such postulate. Presidents are not in the habit of taking a narrow fiscal view of their responsibilities.

A basic reason that the Government applies user charges is that it provides a basis for determining appropriate levels of specific programs. If the price charged for a service reflects the cost of providing that service, we can be more confident that we are devoting the right amount of resources to providing that service.

Balancing marginal costs and revenues, and reflecting this balance in the price of a commodity, is of course the basic principle underlying a free market economy. If someone is willing to pay the cost of providing the service, it should be provided—if not, the service should be curtailed.

A second basic reason for the application of user charges is that of equity. The President of the United States must ask, "Why should the general taxpayer provide the money and other resources which will enable a special group in our society to get special services of particular value to them?" Clearly a number of programs, including national defense, health and educational programs, should be covered by general revenues. As the President said in his recent Budget Message, the freedom, health and prosperity of all mankind are the proper concern of a Great Society. In some cases, particular goals can be achieved more rapidly and with greater overall equity if the general taxpayer and the recipients of a Government service share the cost of the service.

But in many instances, when the Government provides a service to specific groups, and in particular when a service is used by a specific group as one of the inputs in a productive process—whether it is public grazing lands or public highways on which truckers operate—a strong case can be made for charging appropriate fees for the use of these services.

Now what about the specific area in which you have a special interest, grazing fees. Two points are immediately obvious. First, it is a matter of Government policy to collect grazing fees for the use of public lands. Secondly, to date the application of this policy has been far from perfect. We have, for example, a wide disparity in the fees or charges collected for Indian lands, national forests and the public domain. These differences cannot be rationalized on the basis of differences in value obtained from these publicly owned lands. While there may be disagreement as to the precise values involved, few will claim that the present levels of grazing fees represent a fair return to the public for the use of its resources.

The Administration is determined to establish a more appropriate fee structure for grazing privileges. Under the authority conferred by the Taylor Grazing Act, the setting of these fees is an administrative determination. The President therefore can change grazing fees by simple administrative decision. The President feels, however, that this is such an important decision that he will not install a new grazing fee structure before the 1967 grazing year. He expects that the intervening period will be used to develop appropriate charges; ones that take into account variations in quality and other factors. But by next spring a new fee structure should be implemented.

This, then, is the situation we find ourselves in today. We have the unique opportunity to undertake analyses and to start a dialogue which will lead to new and more appropriate fees for the use of public lands, starting with the 1967 grazing season. I hope you will accept part of this responsibility, both on the grounds of equity and because of the value such fees are in helping us determine appropriate levels of investment in our public lands.

If we are to make sound investment decisions with regard to our public lands we need to be able to determine the real value of those lands to the users. One very important measure of value is found in the fees which users are willing to pay. Sound fee levels will provide the Government with a basis to support future investments in the public lands.

We need the views and advice of members of the American Society of Range Management, and others, on this important matter.

Fees And Charges As Tools Of Public Policy — A Discussion[1]

W. GORDON KEARL

Assistant Professor, Division of Agricultural Economics, University of Wyoming, Laramie.

Highlight

This is a critique of the address by Charles J. Zwick. Clearly defining the nature of the fee problem is essential. Ranching is part of agriculture, and grazing fees should be considered as part of total agricultural policy. Basic user charge policies are examined and serious questions raised about their application.

Clearly and adequately defining a problem is the first step to finding a solution. Defining the problem of user fees in connection with grazing is more difficult than generally supposed. It might be regarded as similar to that of user fees for government services such as airports, airways communications and navigation facilities, inland waterways, highways and so forth.

Alternatively, the problem might be limited and placed in a general category of user fees for natural resources types of government activities, services, or resources. In delimiting in this manner, then, the problem is perhaps analogous to that of user fees in connection with national parks and monuments, or water impoundments constructed by the Bureau of Reclamation or Corps of Engineers.

Finally, ranching constitutes a significant part of agriculture in many of the western states. Therefore, the question of user fees must be viewed in part as an agricultural question and specifically as an agricultural policy question. Dr. Zwick brought out the importance of the principle of equity between users in considering user fees. There is also a question of equity between different segments of agriculture in the way in which agricultural programs are applied.

Two Bureau of the Budget documents are relevant to this discussion. These are Circular No. A-25 dated September 23, 1959 and "Natural Resources User Charges—A Study," dated

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[1] *Presented at the Nineteenth Annual Meeting, American Society of Range Management, New Orleans, Louisiana, February 3, 1966.*

June 1964. Dr. Zwick referred to Circular A-25, but discussed its contents only in the most general terms. He did not discuss, or refer us to, the important 1964 natural resources charges study. The first document infers that user fees applied to rangelands are to be viewed in the same light as user fees applied to airports, highways, or other of the approximately 1,500 different user fees. The second document treats user fees for grazing as part of the larger problem of user fees for natural resources. The view that user fees applied to grazing actually are in the area of agricultural policy has been ignored.

Under general policy Circular A-25 states: "Where a service (or privilege) provides special benefits to an identifiable recipient above and beyond those which accrue to the public at large, a charge should be imposed to recover the full cost to the Federal Government of rendering that service. For example, a special benefit will be considered to accrue and a charge should be imposed when a government-rendered service (a) enables the beneficiary to obtain more immediate or substantial gains or values (which may or may not be measurable in monetary terms), than those which accrue to the general public . . ."

Circular A-25 further states that the maximum fee for a special service will be governed by its total cost and not by the value of the service to the recipient. This, incidentally, conflicts with the policy on natural resources.

The preceding quotes have been given to emphasize the position which was apparently taken at times in the past by the Executive Office of the President and the Bureau of the Budget. I think now it may be worthwhile to examine some of the terminology which has been used. The terminology "Federal activities," or "services," or "resources," can all be found in these documents attached to the further terminology "which conveys special benefits to identifiable recipients above and beyond those which accrue to the public at large."

The U.S. Department of Agriculture engages in many such activities and services. The Soil Conservation Service provides many technical services at great expense, and, as far as I am able to ascertain, without collecting user fees. In fact, a second agency, the Agricultural Stabilization and Conservation Service, pays recipients of the technical assistance from the Soil Conservation Service for participation in Agricultural Conservation programs. The amount of assistance from 1956 through 1964, not including salaries or operating expenses of ASC or SCS, has ranged from about $210 million to $239 million per year and was much higher in earlier years.

There can be little doubt that these are federal activities or services which provide special benefits to identifiable recipients. These benefits are both in current income, capital investment, and capital gains. There may be some argument that such special benefits are not "above and beyond those which accrue to the public at large"; although, in my opinion, a good argument can be made that this is true.

Other federal activities or services which "convey special benefits to identifiable recipients" include many price supporting and market regulating activities for crops such as wheat, cotton, tobacco, sugar beets and cane, dairy products, and many other crops produced under market regulations. The individuals who reap a major part of these benefits are those who have accumulated a history over a period of years of producing these products. This is analogous to range users accumulated history on which grazing privileges seem to depend.

The special market which has been created and provided to identifiable recipients is perhaps a little different type of federal resource than the "natural resources" of land. The principle seems to be no different. As far as I know, the "identifiable recipients of these benefits" are not paying user fees for the privileges. They are not paying the administration costs of the programs except for some of the products marketed under marketing orders. The recipients are certainly not paying fees which represent the true market value of the privileges of producing these crops. There remains a question, perhaps, as to whether the "special benefits to identifiable recipients" are "above and beyond those which accrue to the public at large."

A principle enunciated in "Natural Resources User Charges: A Study," the report of the Bureau of the Budget pertaining to federal lands, is this: "Fees should be based on the economic value of the use of the land to the user, taking into account such factors as the quality and the quantity of forage, accessibility, and market value of livestock. Economic value should be set by an appraisal that will provide a fair return to the government and equitable treatment to the users. Competitive bidding should be used to provide reliable guidelines for establishing a fee structure that represents true market value where feasible." The emphasis on true market value or economic value contrasts with emphasis in Circular A-25 on recovering costs.

Dr. Zwick suggests that perhaps the economic value principle might still be applied. He does not indicate how it might be determined, or administered, and these remain very large questions.

If an economic value principle were implemented, ranchers using public lands would be one of the few segments of agriculture to be charged fees for the use of federal activities, services, or resources on that basis. The present subsidy to the livestock grazing interests is small compared to the subsidies and benefits accruing to many of the other segments of agriculture for the use of federal activities, services, or resources, and for which essentially no user fees are being paid.

Dr. Zwick has also suggested that fees should reflect full value as a guide to investment. The criterion that investments made for conservation purposes should be justified on the basis of the value of grazing produced has not generally been applied in the past. It is not completely clear whether this criterion is suggested for future application. It has not been applied, or has been applied only with reservations, on ASC, SCS, or Great Plains programs activities. These programs have all resulted in investments on private lands on a cost-sharing basis. Presumably the farm or ranch operator participating in these programs can justify his share of the investment on purely economic grounds of tangible returns received. The public share of these investments is justified on the basis of extra-market values such as soil and water conservation, and as an income subsidy to agriculture.

Investments on public lands also result in the extra-market values of soil and water conservation, improvement of wild-life habitat, improvement of access for recreation, and so forth. Why should a stringent criterion requiring grazing to cover full costs of range improvements and soil and water conservation investments be applied to public lands? The government is participating in these types of investments on private lands on a much less stringent basis.

Finally, ranch operators have been using public lands for many years. Essentially, they have been in partnership with the Forest Service for 60 years or more and in partnership with the BLM for 30 years. Ranch operators have contributed substantially over this long time period by constructing roads and trails, developing muddy seeps into clear flowing springs, and constructing other forms of stock water facilities. They have also made many other types of conservation investments. These types of developments and investments are proving extremely useful to the general public wishing to use range and forest lands for recreational purposes today. Range users continue to make these types of contributions even now. They provide much of the continuing maintenance and some new construction or development from year to year. These types of activities should not be ignored, and ranchers should receive greater credit for this than they have in the past.

The use of public property by ranch operators is not a one-way street. It is true that private lands and public lands are frequently complementary in use. Productivity of private lands is affected by and to an extent is dependent upon, access to public lands.

By the same token there is much public use and public dependence upon private lands. For instance, private lands lying between National Forests and large blocks of BLM lands provide significant big-game ranges in Wyoming and make a significant public contribution in this respect. Private lands further removed from National Forests are also very significant.

Recreational uses of private lands are another example of public use. For instance private lands provide a major portion of the forage for deer and antelope in Wyoming. Probably more than 50% of the harvest of these animals is from private lands. Frequently convenient access to public lands is obtained only through use, at least through crossing, of private lands. Continuing and increased use of private property for public purposes, especially outdoor recreation, is desirable.

It is good to note the general moderate tone of Dr. Zwick's paper. Others might follow this example. The really significant problems in resource use might best be solved through cooperation, diplomacy, and due recognition of the contributions of private property, rather than through antagonistic recriminations about fee levels.

Relating Ranch Prices and Grazing Permit Values to Ranch Productivity[1]

WILLIAM E. MARTIN[2]
Associate Professor of Agricultural Economics, The University of Arizona, Tucson.

Highlight

The hypothesis is offered that all "outputs" produced by an investment in a cattle ranch have not been included in previous conventional analyses. These other "outputs" include tax shelters, land (and lease) appreciation, farm fundamentalism, and conspicuous consumption. Since these additional outputs are as much a part of the return on investment as is the output beef, they might well be consedered in evaluating use fees on public lands.

Recent research on costs and returns in the western range cattle industry shows returns to capital and management ranging from very low to negative in all areas studied (Caton, 1962, 1965). These results were especially pronounced in Arizona. Here, price per hundredweight of beef exceeded cost per hundredweight only if all interest on investment was excluded as an opportunity cost and if herds exceeded (depending on the area) 200 to 300 cow-units in size (Martin and Goss, 1963). Yet, we note that ranchers continue to remain in business and that ranch sale prices remain at levels so that computed net returns in ranching are negative if an opportunity cost for capital is included.

At the same time that ranchers are apparently producing negative profits, there has been considerable interest by individuals and groups in both public and private life to raise public lands grazing fees. The essence of this argument is that ranchers are now paying less than the full value of the marginal product of the grazing permit as their monthly rental fee to the relevant governmental agency (either the Bureau of Land Management, the Forest Service, or the state land agency).

To summarize, raising beef is not a profitable operation given current ranch sale prices (at least in Arizona); yet, there is continued pressure to raise the level of public lands grazing fees. This pressure exists because of a general belief that grazing fees on public lands are below levels that would prevail in a free, competitive market—that is, below the level of the permit's marginal value product (MVP). (MVP is the value of the additional output produced by the last unit of input applied. An economic optimum is achieved when the user is applying inputs so that the marginal value product is just equal to its cost.)

The importance of public lands to the Arizona cattle ranching industry and to ranch sale prices should be emphasized. Private lands comprise only 20.4% of the State's total grazing area (Jefferies, 1964). In the western desert portion of the State, only 0.4% of a ranch is typically privately owned. In a sample of 66 bona fide ranch sales occurring between 1957 and 1963 in Arizona BLM grazing districts 2 and 3, the BLM Section 15 areas, the intermingled State lands, and the Tonto National Forest, 9.46% of the ranch lands were privately owned. The average sale price for these ranches (including the deeded lands and the public grazing permits) was $932 per rated animal unit if the ranch was stocked and $599 per rated animal unit if no cattle were included in the sale (Jefferies, 1964). Our estimates of reasonable sale prices, given the single objective of raising beef for market, range from $200 to $250 per cow-unit for unstocked ranches if the ranch is large enough to take advantage of all economies of size. Most ranches are not that large and would have lower average values per cow-unit.

The above facts raise the following questions. First, what are the reasons for the high level of ranch sale prices? Secondly, can we measure the relative contributions of the resource components contributing to this sale price? Thirdly, could we use these measurements as a basis to rationalize the levels of public grazing fees? The answers to these three questions have two sets of implications. One is toward a workable fee policy that would extract the full value of the range resources for the public. The second is for economists and range managers in general.

Why are Ranch Sales Prices High?

There seems to be some problem of evaluation, either by the ranchers who are apparently receiving negative returns on their investment, or by we agricultural economists and range managers who usually base our analyses simply on the returns from beef production alone. Either the opportunity cost of capital[3] is not recognized by

[1] *Presented at the Annual Meeting, American Society of Range Management, New Orleans, Louisiana, February 3, 1966. Article No. 1121, Journal Series, Arizona Agricultural Exp. Sta.*

[2] *The author wishes to acknowlege the fruitful associations with his former graduate students, William K. Goss, Gene L. Jefferies, and Jimmie R. Gatz, whose diligent research provided much of the basic data on which this paper was built.*

ranchers or *all returns* to ranching have not been recognized in the analyses.

Both conditions may hold true. First, there are ranchers who purchased or inherited property before the great increase in land values. These people may remain in ranching by sacrificing an opportunity to sell their land and invest the money more profitably elsewhere. They are only sacrificing an opportunity; their cash income may exceed their cash expenses. But what of the people who are purchasing ranches at present-day prices? We would argue that modern day ranching, at least in Arizona, is not simply a business of raising cattle and selling beef. Ranchers are also landholders (and public lands leaseholders) and thus may be speculators seeking capital gains. Where land and leases are held in anticipation of appreciation in value, not all of their costs should be charged against the business of raising cattle. A part of this investment cost is the cost of holding land and leases for speculative purposes.

Also, it has been alleged that the federal income tax laws have made ranching an excellent tax shelter for investors with outside incomes. Here the additional "output" would be the tax savings made possible through converting ordinary income into capital gains. Again, part of the investment and operating costs should be allocated to this other output of the ranch.

There are two other motives which may contribute to the economists' computations of low net income, "ranch fundamentalism," and "conspicuous consumption." The first operates through those groups of people who know no other way of life and/or who romanticize the carefree independent life of the cowboy. Our agricultural colleges in the West are full of this type of student (especially in animal science departments) though we doubt that many will have the wherewithal to affect investment costs much in the future. Conspicuous consumption is probably much more important. Much of Arizona society revolves around the ranching families, and people interested in this aspect of "output" are much more likely to be in a position to also take advantage of the capital gains output.

Thus, we argue that it is unrealistic to compute cattle ranch costs and returns simply on the basis of one output—beef. In addition to beef, there are the relatively nonquantifiable outputs of farm fundamentalism and conspicuous consumption, as well as possibilities for the monetary outputs of tax shelters and ranch appreciation. These outputs are not competitive but are additive. Receiving more of one does not imply receiving less of another. If these additional outputs were included in our evaluation of the costs and returns of cattle ranching, perhaps the prices paid for cattle ranches would appear perfectly rational. Investors are purchasing both a resource to be used for production purposes as well as a resource for personal consumption.

The fact that much of the land being purchased is not deeded land but only the right to use government leases, does not materially alter the results. Control of leases offers the same opportunities for tax shelters, speculation, farm fundamentalism, and conspicuous consumption as does actual ownership of land. Of course, differing tenure rules, as well as different productivity opportunities (both for beef and the "other outputs") affect the sale price of each type of lease.

When deeded land is purchased, the value of that land to the purchaser is the capitalized value of the expected net returns to the land. Similarly, if the value of a government lease is above its rental price, the lease will carry a sale value upon transfer.

It has been shown that under current grazing fee policy there will be a positive value to be capitalized into a sales price for a lease (Roberts, 1963). This is true even if beef production is the only output. But sales prices for leases are very much higher than this difference due to beef productivity alone would warrant.

In the following discussion we will present some numerical estimates of the total size of this difference as well as some comments on the relative size of the factors not related to beef. These estimates may be relevant when people discuss fee setting policy.

Estimating Relative Values of Range Resources

Tax Saving Opportunities.—A study of the possibilities of the Arizona ranch as a tax shelter has just been completed (Gatz, 1965). The analysis looked at net tax effects, independent of land or lease appreciation. Results show that there is a real value to this extra product. However, under current tax laws, this value is not nearly large enough to be the major "additional output" to beef production.

In fact, even if we assume investors in the highest federal income tax brackets (where potential savings would be the greatest) tax savings will rarely average more than 0.5% of the capital investment over time. The percent return would have to be nearer 5% to provide a complete explanation of high ranch prices.

[3] *The opportunity cost of capital is the amount of money that could be made if the rancher were to sell out and invest his capital in some alternative enterprise.*

Lease Values and Grazing Fees.—Since the tax shelter aspect of cattle ranching is not large enough to explain the difference between the ranch's value for beef production and its market price, the expectations of grazing land appreciation, in combination with the consumption aspects of ranching, must be the major explanatory factors. For the moment, let us simply accept that investors each have their reason for purchasing a cattle ranch and go on to analyze the value of each component of land resource on the basis of the investors' actions in the market. The size of these empirical estimates, when compared with other available data, will give us further insights into the relative values of the speculation and consumption components of ranch price.

From 1957 through 1963 a total of about 160 bona fide ranch sales occurred in the Arizona areas mentioned above. The purchasers in 66 of these transfers were interviewed relative to variables affecting the sale price (Jefferies, 1964). Data gathered included items such as date of sale, total sale price, amount of deeded land, types, amounts and qualities of public lands, and number of cattle included in the sale. Other information obtained included the miles of deeded frontage on a main road, the distance from the nearest urban center, the percent of purchaser's gross income that was derived from cattle ranching, whether the purchaser bought the ranch for tax shelter purposes, and the tax bracket of the purchaser when he bought the ranch.

Multiple regression analysis was used to develop equations that would "explain" the sale prices of the ranches as a function of the amount of deeded land, the animal units for each of the forest, BLM, and State permits, the number of animals involved in the sale, and time. The parameters derived directly gave the marginal value of each component of the sale as well as the trend in land values and permit values over time.

(The general form of the equation was:

$P = f(D, F, B, S, A, t)$.

Where

- P is the total sales price of ranch in dollars
- D is the amount of deeded land in acres
- F is the number of forest permits in animal units
- B is the number of BLM permits in animal units
- S is the number of State permits in animal units
- A is the number of breeding animals, one- and two-year-old steers, and stocker heifers sold with ranch
- t is the year in which the ranch was sold.

All animal units were for year-round grazing, and were based on the rancher's actual use of the land rather than on agency suggested stocking rates. This increases the animal units figure on state and section 15 BLM lands by a factor of about two. Other variables such as cattle prices, value of improvements, population-distance indices, frontage of deeded land, and ranch elevation were used in preliminary formulations but proved nonsignificant.)

More than a dozen regression formulations were run in an effort to achieve the best fit consistent with our goal of obtaining the marginal values of an animal unit of grazing permit. Four equations were selected that gave similar results for the regression coefficients, none of which could be said to be more satisfactory than the other. Final estimates were computed by averaging the results of these four equations. The multiple R^2 on these equations varied from .62 to .67; all coefficients were statistically significant at the one percent level of probability. There was no problem with multi-collinearity. Partial correlation coefficients between the independent variables ranged from zero to .47.

Our estimates of the marginal permit values are as follows: Forest Service—$274.56 per animal unit; BLM—$154.79; and State—$302.44/AU. Deeded lands carried a marginal value of about $18/acre. These values may be converted to an AUM basis by dividing by 12. This would make an estimated market value of $22.88, $12.90, and $25.20/AUM for Forest Service, BLM, and State permits, respectively.

These values represent an estimate of the capitalized value of the difference between public grazing fees in Arizona and the apparent marginal value product of the public grazing permit, (that is, their full competitive value), as expressed by the investors themselves in the market place. It is the total value and not just the value due to the production and marketing of beef.

Discounting procedures may be used to convert our capitalized marginal values in terms of sale price into marginal values in terms of permit fees. For example, if a rancher is willing to pay $280/AU for a forest permit, then this amount must be the capitalized difference between the fees charged by the Forest Service and the expected annual net returns from having possession of the permit. (Annual returns are here defined as total

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[4] *The simple capitalization formula is:*

$$V = \frac{R}{r}$$

where V is the present value of a stream of future revenue, R, forthcoming at a constant rate per year over an infinite period of time; and r equals the appropriate market rate of interest.

Algebraic manipulation gives us the discounting formula used in this analysis:

$$R = V r$$

where R equals the discounted fee differential; V is the sale value of the permit (obtained from the regression analysis); and r is the discount market rate of interest.

returns less utilization costs not including grazing fees.)

When discounted at 6%, a $280 sale price becomes equivalent to a $1.37 monthly fee.[4] This value represents an approximation of the actual difference between the forest grazing fee in Arizona and the apparent marginal value product of the permit, that is, its full competitive value.

The MVP of each type of grazing permits (less nonfee utilization costs) may be computed by adding the fee to the difference (Table 1). For example, if we use a discount rate of 6% and the 1962-63 grazing fees, the net value is estimated to be $1.75/AUM for forest lands, $1.08 for BLM lands, and $1.91/AUM for State lands.

Ranchers are effectively paying the above fee rates right now. For new owners most of the payment goes to private individuals in the form of a sale price. For old owners the major portion of the rate is in the form of an opportunity cost.

Private Rental Lands and Lease Appreciation.—Contrary to our expectations, our statistical analysis showed no significant trend in ranch sale prices over the last seven years (Martin and Jefferies, 1965). Graphic analysis in terms of sale value per cow-unit suggests that prices continued to rise until 1959 and have remained stable since. If expectations of rising land and lease values have been a factor contributing to high purchase prices, these expectations have not lately been realized.

Another view of the land and lease appreciation problem may be had by comparing the discounted prices of government grazing leases with monthly rental fees for private lands.

Gardner (1962) reported that private rental fees were somewhat higher than the discounted value of government permits. He attributed the values of both the private and public grazing lands strictly to their beef producing potential. The difference in value suggested to him that public lands were being misallocated among potential beef procedures.

However, if our hypothesis about extra outputs on public land is correct (and if private lands were rented strictly for their beef producing potential), we would expect the actual values for public lands to be *higher* than for private rentals. These values are not higher; we doubt that misallocation could be the whole answer.

Even more peculiar, rental fees on private grazing lands, when converted to a present value sales price equals $649/AU (Gardner's average rental fee capitalized at 6%). Evidently, private lands are not rented merely for the purpose of profits from beef production either! This single purpose would imply sale values of only $200-$250/AU.

Why are people willing to pay such high monthly rental fees for private grazing lands? The answers must be much the same as for the purchases of government leases. They may need rental land as part of a tax shelter. While the opportunities for tax savings on private rental lands differ from those on government leases, they still exist. You do not need to own the lease for ranch fundamentalism and conspicuous consumption. Furthermore, because of economies of size in cattle ranching, the marginal value product of an additional block of rental land may be considerably higher than the average value product of the whole ranch. Most ranches are much smaller than the size where long-run average costs become constant (Martin and Goss, 1963). (Because large ranches can produce beef at a lower per-unit cost than small ranches, it may often make sense for a rancher to pay very high prices in order to expand his present operation. He could not afford to pay this same per-acre price for a complete operation.)

The major difference is that renters of private lands have no opportunities to reap the benefits of lease appreciation. But since private rental rates are comparable in size to the discounted value of lease sale values, it suggests that expectations of land appreciation may not loom large in investors' decisions to purchase a lease. Since tax shelter opportunities are not large relative to the differential to be explained, the major reason for high ranch prices must be the consumption related outputs.

Table 1. Capitalized values (in dollars) of AUM of grazing permits, Arizona, 1957-1963.

Type of permit	MVP of grazing permit minus actual fee Difference valued at 4%	5%	6%	Average fee for 1957-1961	1962-1963
Forest	.92	1.14	1.37	.36	.38
BLM	.52	.64	.78	.20	.30
State	1.01	1.26	1.51	.37	.40

Summary and Conclusions

It was shown that government grazing land leases have a market value considerably above their monthly rental fee. This value is capitalized into a transfer price for the lease. This extra value cannot be explained by the value of the land for beef production alone. Neither is the full explanation due to the value of a ranch as a tax shelter nor the expectations of land and lease appreciation. Apparently these high ranch prices are not based on the profit motive. Rather, ranch purchasers are simply paying for the privilege of being ranchers.

The final question is this—could our public agencies charge rates equivalent to what purchasers are now paying in the market as a monthly grazing fee without reducing the use of the public range below its present level? Certainly not. These estimates are based on market prices. The majority of people now holding ranches could not afford to pay such prices in cash even though they are willing to pay the price in opportunities foregone. Such a rate level would have the effect of putting all public leases on the market at the same price now being paid for leases on the margin.

Higher fees could be approached in a step-wise fashion; but, even if differences in location, type of grazing, and other quality related variables did not exist,[5] all ranches could not afford to pay the same grazing fee. As long as economies of size exist, the value of an extra unit of grazing will differ between ranches. Even more importantly, the value of the "other outputs" is more closely related to the income position of individual potential investors than to the grazing potential of the range. Since it is impossible to know the income position of all possible investors (even if we could know the beef producton function for each range) neither flat fee levels nor even fee formulas based on physical production criteria could eliminate the capital value of all leases without drastically reducing the use of the range.

Since the market remains the final arbiter of price no matter how complicated our institutional rules may be, how much simpler it would be if grazing permits were simply put on the block to the highest bidder—perhaps in conjunction with a floor price high enough to keep the bidders honest[6]. This procedure would extract the competitive market price of the public range for the public coffers, allow our citizens to compete for the consumption aspects of the ranching industry, and at the same time keep our ranges producing beef.

And how much more rewarding it might be to us economists and range managers to acknowledge that ranching is a complex investment in several outputs. Such an investment requires a great deal more analysis than our traditional analyses related only to the most obvious products—grass and beef.

[5] *Roberts and Topham (1965), have developed equations showing differences in user costs between various types of Utah ranges.*

[6] *Such a procedure is outlined in detail for state owned federal grant lands in Wennergren and Roberts (1965). This procedure could apply equally as well to federally controlled lands with only minor adaptation.*

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Management Features

(Editors Note—The following five papers were presented at the ASRM Annual Meeting in New Orleans, Louisiana, February 1 to 4, 1966. They are longer than the usual Management Notes in the Journal, and are published here as a group because they should interest ranchers and other practicing range managers. The papers by Edwin E. Marsh and Floyd F. Higbee were presented in a panel discussion of "Current Challenges in Range Management." The papers by J. L. Schuster and R. C. Albin, George Skeete, and Jim Wilson were given at similar sessions of interest to rangeland managers.—*R. S. Campbell.)*

Sheep Ranchers Adjust to Change[1]

EDWIN E. MARSH

Executive Secretary, National Wool Growers Association, Salt Lake City, Utah.

The raising of sheep is one of the oldest professions known. In some parts of the world, sheep are still tended as they were many centuries ago. Some may feel that our domestic sheep industry is not as progressive and not as alert to make changes as it should be. Nevertheless, the history of the sheep industry of the United States over the past 100 years shows that considerable strides have been made and that our sheepmen do adjust to change.

Range Improvement

Perhaps the two most important areas of activity in range improvement are in brush removal and range reseeding. Increased carrying capacity per acre is a "must" in view of high and increasing costs of operation. Although considerable progress is being made in brush removal and control, much work lies ahead.

Many sheepmen are working on their brush problems and are seeking information on brush removal and control from local, state and federal sources. They are seeking the cheapest and most effective combinations of chemicals and mechanical measures to solve the particular brush problem in their area. Brush removal methods presently involve chemical spraying, chaining down of stumps and root-plowing.

Certainly, sheep ranchers need continued help of researchers, as well as assistance from equipment and agricultural chemical companies, to find less costly and more effective methods of controlling unwanted plants while at the same time safeguarding useful vegetation on croplands, grazing lands, forests, wildlife areas, recreational areas, rights-of-way, parks, urban developments, canals, and industrial areas.

The range improvement work of George Skeete of Water Valley, Texas, is a good example of a sheep rancher who is adjusting to change (see his article on page 258 of this issue). Mr. Skeete operates a ranch carrying 5,200 sheep, all native range. With the assistance of the Great Plains Conservation Program, he has cleared his entire ranch of mesquite, other brush and pricklypear. During the past ten years, he has substantially reduced the need for feeding his sheep during the winter season. He has reduced death losses and labor costs. He has controlled runoff from rain. Through brush control and maximum utilization of water in 1960, he was able to start a spring flowing that had been dry for over 20 years. Best of all, he has a good program of range management follow-up. George firmly believes in sound range management and proper use of the grass.

Livestock producers generally report that forage production has been increased by 30 to 100% as a result of the application of brush control treatments. Reseeding following brush removal is also a common practice and one that is increasing the carrying capacity per acre. In some areas, the increase in carrying capacity has been spectacular. There is also increased interest in fertilizing of rangelands by airplane and of pasture lands by conventional methods as a vital means of increasing the carrying capacity. Such practices often extend seasonal grazing and permit better management of all forage resources.

Progressive sheepmen also realize the importance of full utilization of their resources without damaging over-use or nonproductive use. This means distribution of the sheep over the range so that the forage is harvested uniformly. Ranchers are realizing that one of the ideal methods of obtaining complete distribution of sheep over the ranch is to have permanent watering locations distributed so as to require a minimum of travel by the grazing animals. Sheepmen in fenced areas are finding that if there are several watering locations in each pasture, the ewes will distribute themselves in groups at each watering trough, reducing congestion and overgrazing. Lambing percentages have been found to be best in pastures with several places to water. Drilling wells to obtain additional watering spots is costly. The advent of plastic pipe has solved this problem in some areas and here again sheepmen are adjusting to change. For example, over 1500 miles of plastic pipe have been laid on sheep and cattle ranches in New Mexico, to distribute water evenly around pastures. One of our progressive eastern New Mexico sheepmen increased from 58 to 80% the area of his ranch within one mile of water. By installing six more miles of plastic pipe he will bring 87% within one mile of water.

Another very progressive sheep outfit in New Mexico, the Floyd Lee ranch and the Fernandez Company, located west of Albuquerque at an elevation of 7100 ft, had a real problem with watering troughs freezing over in the winter. They solved this problem by using the sun to warm water; that is, by installa-

[1] *Presented at 1966 Annual Meeting, American Society of Range Management, New Orleans, Louisiana, Feb. 1-4.*

tion of solar water heaters in a manner similar to solar heating of homes in Florida. This system was described at the National Wool Growers Association convention in January 1965 and we have had many inquiries from sheepmen since that time asking for plans of this water heating system.

Fencing of both private allotments and Federal grazing allotments is on the increase. Every year we see less herding of sheep on the open range and more grazing of sheep under fence. Fencing is a means of reducing labor costs and also a solution to the problem of the growing shortage of qualified herding labor. One sheep rancher in Oregon who has fenced his entire year-around operation, including his National Forest allotment, told me that for every herder he could do without for a year, he could build 12 miles of fence. The Forest Service has cooperated on this project and I feel sure that this agency is pleased with the fenced, herderless type of operation and the good, even utilization of the range that results. I went over a good cross-section of this man's allotment on the Fremont National Forest in Oregon and out of 2,000 head of sheep on this particular section, we saw only about ten head. This is indicative of the fact that sheep are spread out and do make good utilization of the range. Again, sheepmen are adjusting to change.

Lamb Improvement

Sheep producers are also seeking to develop even better lamb carcasses than they now produce. This is evidenced by the fact that through the National Wool Growers Association an Industry-wide Lamb Planning Committee has been established. The main objective of this committee is to work for production of lambs which more nearly meet changing demands of the consumer. Another objective is orderly marketing, insuring a more constant supply. A goal has been established with specifications for desirable carcasses, and growers, through careful selection of breeding animals, can bring their production closer, at least, to these specifications.

One of the new tools being developed to measure the internal characteristics of live sheep, especially the loin-eye area, is an ultrasonic device known as the Sonoray machine. The purpose of making such measurements is to aid in selection of progeny that will produce carcasses yielding cuts most preferred by consumers. For example, one of the needs is for meatier lamb chops, those with a larger loin eye. The Sonoray, while still not perfected, holds promise in this field.

Research is also under way to determine whether it is possible to raise two lamb crops a year, or three lamb crops in two years. Sheepmen are following this research closely because if it proves to be practical and feasible, it could help to solve the problem of how to raise production per unit in order to decrease costs. I stress that this is still in the research stage, but a development which sheepmen are watching in the interest of greater production efficiency.

In fact, the need for further increases in unit efficiency has also inspired research now under way to determine the feasibility of bunching the lamb crop. One of the advantages to having more lambs born in a shorter period of time would be a decrease in the cost of production. Labor costs have increased to the point where some growers are no longer shed lambing. An increasing number of growers, even as far north as Montana, are lambing in pastures. This has not been done previously in northern areas because of the cold, wet spring storms. If a grower could bunch the lambing of 1200 ewes into three groups of about 400 each, for example, he could probably take better advantage of his sheltered lambing facilities and available labor. In this

FIG. 1. Type of ewe and fleece that Wyoming sheepman George LeBar is selecting for in his wool improvement program.

case, bunching of the lamb crop might give good returns. Again, this is in the experimental stage looking toward future gains in production efficiency.

Wool Improvement

There is no question about the production of clean wool per head being one of the more important factors in determining profit or loss in the sheep enterprise. While sheep producers have for some years now carried on sound selection and breeding programs to increase their yields of clean wool, I'm happy to say that this improvement work is still under way to gain further yields per head. A flock in Hyattville, Wyoming for example, which yielded only 3.04 lb. of clean wool per head in 1938, yielded 4.9 lb. in 1964, a 61% increase in that 26-year period. This rancher, like many others, is continuing his selection work to obtain even higher yields (Fig. 1).

Growers, through our organization, have also established an Industry-wide Wool Planning Committee. Objectives of the committee are to work for better preparation for market of the domestic wool clip. This involves elimination of jute and other extraneous contaminations, elimination of unscourable branding fluid, black fibers, tar and chemical stain; separate packaging of tags, crutchings, face and hock wools, improvement in shearing techniques, tying procedures and improvement of the individual wool package. Again, sheepmen are adjusting to change.

Conclusion

In the 20 years that I have worked with sheepmen, I have found them to be a somewhat conservative group. Many of them will try new methods of doing things only if they can see that these new methods are feasible and profitable. Some, who have ventured forth into new methods, have found that change is not always profitable. For example, some years back, several sheep ranchers decided to adopt the Australian method of preparing their wool clips for market. They sorted, graded and skirted the wool at the shearing corral and did all of the other things involved in superior preparation and packaging of wool for market. However, they discovered that the premium offered by the mills for this better preparation was not sufficient to compensate for the increased labor costs and other expenses involved. Here, then, was a practice that was not profitable, or at least one which at that particular time did not prove profitable.

There are a number of research projects being conducted by laboratories, universities, the federal government, and ranchers themselves, which may never produce anything practical. And yet out of the multitude of research projects, if we can come forth with a few practical and profitable ideas for the sheep industry, then I know that sheepmen will adopt these new ideas and adjust to change. I base this assumption on the present-day changes that are under way. I base it also on past history which shows that:

1. Lamb and mutton marketed per stock sheep has doubled in the last 50 years.
2. Lambs saved per 100 ewes increased from 85 to 89 in the 1920's to a five-year average of 96 from 1956 to 1960.
3. Fleece weights increased from an average of 3.25 lb. at the time the National Wool Growers Association was organized in 1865 to an 8.5 lb. average today.
4. The average live weight of sheep and lambs at slaughter has increased from 90 lb and less before 1945 to 97 and 98 lb since 1958.

Yes, sheepmen do adjust to change.

* * *

NOTICE

Spanish summaries of 1965 Journal articles have been translated by Dr. Martin Gonzalez and published at Texas Technological College for the Society. Copies have been mailed to all Society members in Spanish-speaking countries. Other Spanish-speaking scientists and ranchers may obtain a copy by writing Dr. Thad Box, Range Management, Texas Technological College, P.O. Box 4169, Lubbock, Texas 79409.

Opportunities In Range Management Through Association[1]

FLOYD F. HIGBEE

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Highlight

Small farmers and ranchers are forming grazing associations and buying land with funds advanced through the Farmers Home Administration. This article lists benefits accruing to association members and tells how economic feasibility of such projects is determined.

Table 1. Farmers Home Administration Grazing Association loans, cumulative through May 31, 1966.

State	No. of Associations	Amount Loaned	Acres in Grazing	No. of Families
Arkansas	1	$ 28,000	400	10
Colorado	21	14,517,360	650,000	804
Idaho	9	1,440,700	35,072	79
Kansas	2	513,600	13,927	20
Montana	14	5,923,440	345,409	277
New York	1	15,000	286	7
South Dakota	30	4,908,120	156,545	274
Utah	1	275,000	12,600	25
Washington	1	103,380	2,327	40
Wyoming	8	4,171,710	446,434	130
TOTAL	88	$31,896,310	1,663,000	1,666

During the past three years the Farmers Home Administration has been helping groups of small ranchers and farmers purchase grazing areas as such areas come on the market.

From March 1963, to May 31, 1966, approximately 1,666 farmers and ranchers in 10 states formed 83 grazing associations and with funds obtained through the Farmers Home Administration borrowed $31,896,310 to purchase or lease 1.6 million acres of grazing land (Table 1).

Approximately 250 applications were being considered as of May 31, 1966.

The applications were filed in 31 states and Puerto Rico: New York, Pennsylvania, Illinois, Kansas, Michigan, Minnesota, Missouri, Nebraska, North Dakota, South Dakota, Alabama, Arkansas, Florida, Georgia, Kentucky, Mississippi, North Carolina, Oklahoma, South Carolina, Texas, Virginia, West Virginia, Colorado, Idaho, Montana, New Mexico, Utah, Oregon, Washington, and Wyoming.

The genesis of the grazing associations springs from the problem small ranchers in increasing numbers bring to the county supervisors of the Farmers Home Administration—the problem of lack of sufficient land resources to carry on an adequate, well-balanced farm and ranch operation.

When a number of small farmers and ranchers in the same area present the same need the county supervisor encourages them to seek the solution by organizing a committee to discuss the advisability of forming a grazing association. The first responsibility of the committee is to locate a desirable and feasible grazing tract.

The county supervisor works closely with the committee and by the time a suitable tract comes on the market the group is well informed about all the steps needed to set up and operate a grazing association. They understand that an elected board of directors will decide how the grazing area will be managed and that a manager hired by the board will carry out their decisions.

The negotiations to obtain options and ultimately purchase the land are carried on entirely by the committee. Usually the membership of that committee becomes the first board of directors of the association.

The organization and operation of a grazing association is relatively simple and its activities are in no way dictated by the Farmers Home Administration.

The organization and operation of a grazing association is identical with that of the nonprofit associations the Farmers Home Administration finances for the development of water systems, sewer systems, recreation areas, and senior citizen housing.

The benefits that accrue to the members are many:

1. Membership in a grazing association often represents the only remaining opportunity for the small rancher to increase the size of his operations and to stay in business. He needs more land, but the possibility of buying a ranch when it comes on the market is out of the question. However, the prospect of buying a ranch in cooperation with forty of his neighbors is a different matter. Especially when the Farmers Home Administration is able to provide the financing.

2. A farmer participating in a grazing association has more flexibility in planning the use of his crop land and home pasture land.

3. The farmer member of a grazing association is able to spend maximum time with crops during peak seasons while the manager hired by his association looks after his livestock.

4. Measures to control noxious weeds and rodents can be more effectively carried out on association grazing land and on the

[1] *Based on a paper presented at the Annual Meeting, American Society of Range Management, New Orleans, Louisiana, February 2, 1966.*

home tract pastures when both tracts are idle during portions of the year.

5. Careful sire selection by a committee of association members will result in improved quality of livestock for most members of cow-calf associations.

6. Association grazing provides a greater number of uniform high-quality animals available at a central location at one time, thereby attracting more buyers and creating a stronger market.

7. Unlike the usual lease fee a rancher pays for grazing land, a portion of the fee he pays for the use of his association's land builds his equity in the association's property. This membership equity can be sold or traded in accordance with association bylaws.

8. The stability of tenure afforded through grazing association membership provides a stability of operations, an opportunity to stay with a long-range management plan, that is not present when the rancher is dependent upon leased grass.

Further benefits arise from the requirement that a shift in land use take place each time the Farmers Home Administration finances a grazing association.

The possible land-use shifts that can occur when a grazing association is established are many.

The most obvious shift is the reseeding to grass of marginal cropland within the area purchased. This shift eliminates a soil erosion hazard and cuts down the production of surplus crops. If the cropland was used to produce winter feed, the production of this basic resource will be transferred to the member's headquarters unit, usually with improvement in the quality of the winter feed. It has been contended that the reseeding of cropland to grass will in itself increase livestock production and thus promote another surplus. This is unlikely since even marginal cropland will usually produce more pounds of meat than the same land will produce when used for grass.

A second land-use shift on some units is the use of native hay meadows for grazing, since winter feed will be supplied by the headquarters unit. This practice is a more efficient use of forage, and more important, the meadows will always have a relatively high carrying capacity even in dry years. This promotes protection of the upland ranges in dry years and permits more flexibility in rotational use under ordinary circumstances. The general result is more stability in the year-to-year carrying capacity of the whole unit.

A third and most important shift is better conservation and management. It will take a good many years of careful management to restore many thousand acres of over-grazed and frequently drought-ridden ranges in the West to something like climax condition. The more important management practices include deferred rotational grazing, better distribution of water, cross fences, brush control and control of run-off. Since the grazing associations are encouraged to take full advantage of all of the assistance available from government agencies, substantial progress in better range management can be anticipated.

The development of recreation areas is another potentially significant way to make multiple use of grazing lands. Uses that are being developed include hunting, fishing, picnic areas, faciltities for riding clubs and skiing. Location of the land and seasonality of the recreation, of course, control the extent of these possibilities. The feasibility of development will vary between the plains and hill country units.

In our opinion the most important shift in land use occurs on the member's headquarters unit. If the member is basically a crop farmer the grazing association permits him to add a livestock enterprise or increase his existing livestock operation. This will give him an opportunity to convert his own feed crops to meat instead of selling his ensilage and grain to be fed off his farm. If he develops his feed reserves he will be flexible enough to market some or all of his marketable stock at almost any season of the year, ranging from calves in a cow-calf outfit—to short yearlings—to fall yearlings—to warmed up feeders—to full fed slaughter cattle.

If the member is basically a small livestock man he is provided with the opportunity to better manage his existing resources by grazing rotation, by better protection of his winter range, and by the opportunity to carry his steer yearlings and replacement heifers.

Economic Feasibility

To determine the economic soundness of a grazing association loan we use four general guidelines:

1. The price of the land to be purchased cannot be greater than the present market value of comparable land in the area.
2. The annual grazing use fee alone may not be greater than typical grazing fees in the community.
3. The fees charged by the grazing association must be large enough to support annual operating costs, to pay taxes, meet annual installments due on principal and interest, and provide for a reserve fund to cope with unforseen contingencies.
4. The individual member must be able to use the resources provided by the grazing association to the advantage of his established

farm and ranch operations.

In some quarters the question has been raised as to what steps the Farmers Home Administration would take if the grazing association was unable to make the payments on the loan. If, after all of the best efforts of the agency and the association were exhausted, and no way could be found to keep the association in business, we would dispose of property to small farmers and ranchers. In no case would the land become government property for more than a very short period.

This is not a government land acquisition program but a credit tool to serve family-sized ranchers and farmers.

The response to the formation of these grazing associations has been heart warming.

The members naturally are grateful for the chance to get the extra land resources and are making effective and economical use of their resources.

But we have received equally enthusiastic response from the communities that lie nearby.

By and large the businessmen, the civic and political leadership of our rural communities, are well aware of the damage that is done to the rural community when the land in the community falls into the hands of a few. Community leaders are quick to sense the stability and the increase in local economic strength that comes when the land returns from the hands of one absentee owner to the hands of a score or more of local farmers and ranchers.

We have seen cases where young families were able to stay in the community because they were able to obtain needed land through the local grazing association. Their greatest opportunity is in their local community.

The significance of this local leaders understand.

The grazing association loan program along with the other loan programs of the Farmers Home Administration such as the association loans for sewer and water helps build the local economy in rural communities and improves the equality of living in these communities to prevent their decay and loss of population.

These loan programs go far in furthering two of the Farmers Home Administration basic objectives — developing efficient family farms and ranches and strengthening the rural community.

Can Ranchers Adjust To Fluctuating Forage Production[1]

GEORGE M. SKEETE
Rancher, Water Valley, Texas

Highlight

Experience in the Edwards Plateau area of West Texas since 1960 demonstrates that soundly planned range improvement and ranch management make it possible to operate profitably and to adjust to fluctuating forage supplies.

The West Texas rancher's problem of adjusting stocking rates to widely fluctuating forage production is a most difficult one. This problem is not unique to our ranching area. It is common in varying degrees wherever range grazing is practiced. However, due to our erratic rainfall and other climatic factors, we feel that it poses greater problems here than in areas more favorably blessed with rainfall. The need for flexibility in adjusting stocking rates, as well as when and how adjustments should be made, is an important consideration for every ranchman to know so he can, in fact, achieve efficient use and management each year and finally to truly become a conservation rancher. This, in my opinion, is the first step toward becoming a successful ranchman.

Those who are familiar with the wide climatic variations in the more arid sections of West Texas, or for that matter, of most of what we know as the western rangelands of the entire United States, can well appreciate the need to educate range users in this most important facet of proper and profitable range use and management. For this is undoubtedly a most urgent responsibility of all educators in this field, both those technically trained and also laymen such as, for example, Soil Conservation District Supervisors.

Increasingly my sympathy goes out to you educators and research people, for you have tried from the first to teach us this most important lesson. You surely must have often cried out, as did Moses to the Hebrew people as they neared the promised land, "You have been a rebellious people from the start." All too often we have heard ranchers referred to as conservationists when they have merely applied one or more conservation practices, such as brush control, for example, with little or no regard to follow-up management.

Unless we ranchers can come to recognize the need for managing our forage on the basis of each season's production, all your research, all your efforts as educators, most of the Govern-

[1] *Presented at the Annual Meeting, American Society of Range Management, New Orleans, Louisiana, February 1-4, 1966.*

ment's cost-share assistance expenditures, as well as the rancher's efforts, time, and money, will in almost all cases be unproductive.

For a moment let us look at the area of West Texas adjacent to San Angelo where we operate our ranch in what is known as the Edwards Plateau. This is an area of over 22 million acres of grazing land. We have an annual average rainfall of 19.5 inches around San Angelo. This area is subject to recurring droughts which are sometimes of extremely long duration. It has a high evaporative rate of 60 inches per year due to long hot summers and prevailing hot, dry winds from southwest.

Several writers have recorded the history of grazing use in this vast area. Their comments about the productive capacity of this formerly lush pastureland of 100 years ago are fascinating to the point of being almost unbelievable. They all picture what is now in many cases semi-desert land as being a prairie of grass largely free of brush except for very scattered stands along the creeks and in the valleys. My father-in-law, Mr. J. R. Mims, who was cowboying in the Edwards Plateau before the turn of the century and is now past 93 years of age, told me that it was then difficult to find enough wood for their chuck wagon campfire!

The blame for deterioration of these ranges must be placed almost entirely upon man's lack of knowledge of the nature and care of grasses, his indifference, and/or his greedy desire to get it all as fast as possible. Of course, the recurring droughts, then as now, hastened and compounded the impact of the continuous serious overuse.

Bray's "The Vegetation of Texas," written in 1905, includes the following statement: "Grazing interests have caused profound changes in the density and vigor of prairie formations and the species composing them. Ranges have been denuded which were formerly covered by luxuriant grass formations. Large areas are now subject to harmful erosion and weeds, inferior grasses and many woody plants have supplanted the original valuable species to a marked degree." That was written in 1905. What would he say if he could see these lands today? And H. L. Bentley, writing in 1898, said that some of the more observant ranchers thought range damage then had gone almost beyond the point of redemption!

The decline in the carrying capacity of some rangeland in the Edwards Plateau is well documented from close records of Substation #14 of Texas Experiment Stations, as reported by Dr. Leo B. Merrill, Range Scientist. There on 3,462 acres between Rocksprings and Sonora, the land use treatment was about the same as on the average ranch until 1948. The stocking rate in 1900 was about 125 animal units per section. At the time the land was purchased for a research station in 1916, the rate was 100 AU/section. Constant yearlong heavy grazing, during the interval 1900 to 1948, caused a continuous decline in the carrying capacity of the average rate of 1.5 AU/section, per year, until in 1948 this land had lost over two-thirds of its former productive capacity. When a grazing study was started in 1948, it was estimated that 32 AU/section was about the safe carrying capacity of the range at that time.

Grazing trials established at the Sonora Station in 1948 included yearlong heavy grazing at a rate of 48 AU/section; yearlong moderate grazing at a 32 AU; yearlong light grazing at 16 AU; and a four-pasture rotation-deferred grazing system with a stocking rate of 32 AU/section. Since 1948, the carrying capacity of the heavily grazed yearlong pasture has declined to 30 AU/section. The carrying capacity of the moderately stocked pasture has increased to 35 AU; the lightly grazed pasture to 40 AU; and the rotation-deferred pastures to 43 AU/section. (Fig. 1.)

Dr. Merrill (1959) summed up these data as follows: "Notice that the decline in carrying capacity had continued on the heavily grazed pastures; but in the moderate, the light and the rotation-deferred grazing pastures the decline has been halted and an increase in carrying capacity was obtained. It is significant to note also that even though 32

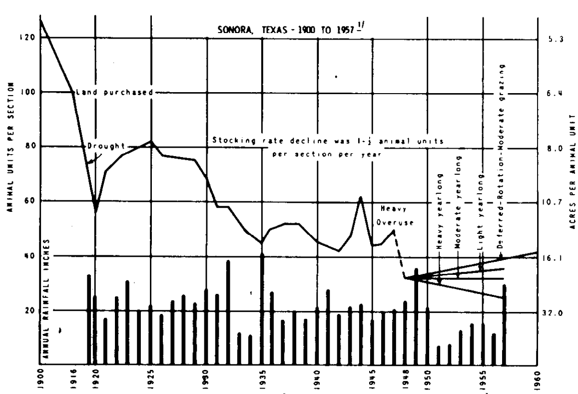

FIG. 1. Average stocking rates at Ranch Experiment Station near Sonora, Texas from 1900 to 1957 showing steady decline until improved management plan was started in 1948.

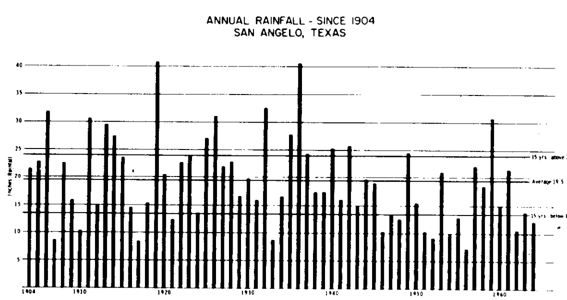

FIG. 2. Annual rainfall at San Angelo, Texas from 1904 to 1964, showing recurring drought periods.

AU were grazed on the rotation-deferred grazing pastures, the carrying capacity increased to 43 AU, whereas yearlong grazing of only one-half as many (16 AU) showed an increase to only 40 AU. How well this illustrates the value of good management systems that make it possible to increase livestock numbers that can be grazed on a given area and yet still permit range improvement."

We have thought at some length now about the impact that constant too heavy grazing plays in depleting range productive capacity. This is the human factor—one that could have been controlled!

Now let us look at the rainfall, temperature, and drought period factors. (Fig. 2.) We can't control these factors so we must adjust to them. The extremes in these variations and the recurring periods of drought shown on the chart should clearly indicate the urgency of flexibility in stocking rates in this particular area. The average rainfall during the past 60 years is 19.5 inches, but during 15 of those years or 25% of the time rainfall was less than 13.5 inches. During 20 years, the total was below 15 inches, and in five years it was below 10 inches. But in contrast, rainfall during 12 years was above 25 inches. These sharp peaks and recurring ups and downs can be considerably minimized by good management but it is periods such as 1950-1956 when the average for seven consecutive years was 12.5 inches or seven inches below the long-time average that really challenge our management skill and tenacity.

There are other factors which directly and often critically influence our forage production. The distribution of the rain is often even more important than the total amount received. The normal relative growth curve one might expect from warm season grasses under average moisture conditions is shown in Fig. 3. Many of these grasses normally make 70% of their year's growth by July 1 in this area. So we see the critical influence that the time rainfall comes and temperature play in affecting plant growth. It can be readily seen that the normal low rainfall and extremely high temperatures generally cut production a good 50% in August. If we don't get our spring rains, we seldom have a good crop of grass.

A review of all the factors that influence forage production leads us to realize that there just isn't any such thing as a safe constant normal carrying capacity in a country where three consecutive years of clipping tests showed forage yields of 1,361 lb, 980 lb, and only 371 lb/acre. Trying to stock constantly at a rate considered "normal" will surely bring on disaster in years of low production unless we have carried over some reserve grass through a deferred grazing system to cushion the extreme years.

It is unfortunate that many ranchers in our area, even now, continue to look upon range deferment somehow as a loss. They understand the principle of putting money in a savings account—just setting it aside to be enlarged in value—so that they might have a reserve for the emergencies of life. Still, they can't see deferment of the grass in their pastures as exactly the same principle! It is only set aside to reseed itself, to improve its vigor, and its root system, and to increase total tonnage to be used later—perhaps at a time when the need is far greater.

Now let us try to determine how the rancher can cope with these vexing and widely fluctuating forage production problems.

As we examine the forage production chart (Fig. 4), let us think of how best to manage a base or foundation herd suited to a given rainfall average and the expected forage which that level of rainfall normally should be expected to produce. Note that a base breeding herd suited to 1,000 lb/acre of range forage, over the years, would require little or no reduction except possibly during unusually dry periods such as the drought of the 1950's. But, this system of planned stocking rates does provide flexibility through opportunities to add stock during years of above average forage production. Thus, in the good or above average years the extra forage can be economically and safely utilized by increasing livestock in various ways that will be discussed later.

But never let us forget that if we try to set a constant stocking rate based upon an above average level—say of 2,000 lb—good years and bad, then we are surely heading for trouble, for this was so well illustrated in the records at the Sonora Station prior to 1948 (Fig. 1).

Referring once more to Fig. 3, we need to select a period in the

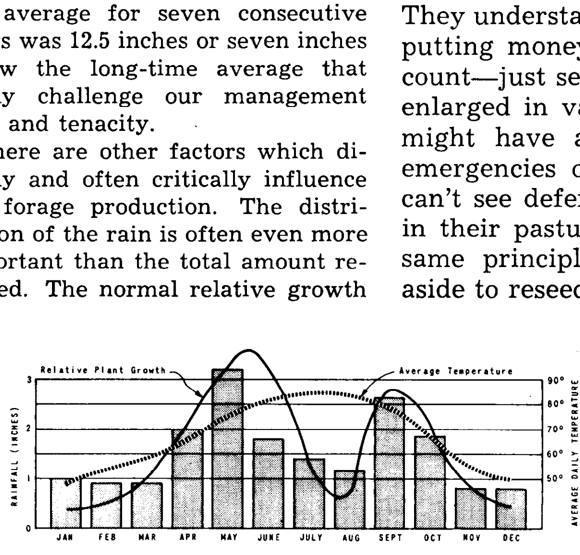

Fig. 3. Average monthly rainfall, temperature and approximate average forage growth curve at Sterling City, Texas.

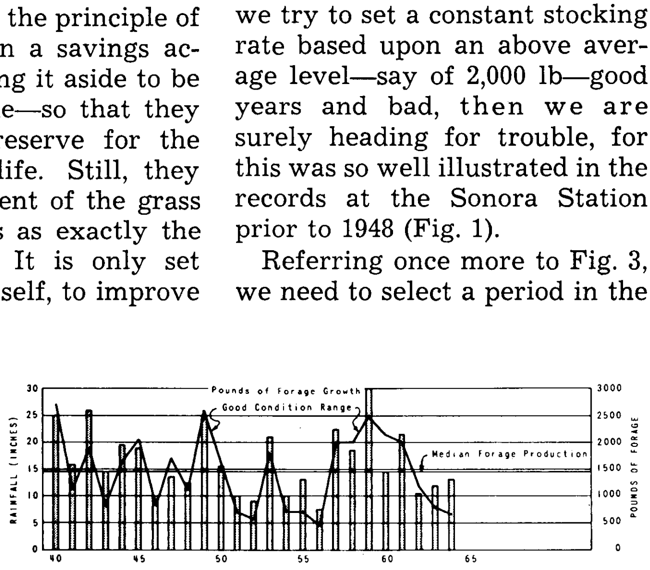

Fig. 4. Year to year fluctuations in forage production from 1940 to 1964 at Sterling City, Texas.

year, such as August in our area, when normally most of our seasonal forage production will have already been made. Now if we did not receive our normal rainfall in the peak production months of April, May and June, or if we have overused our production at this point; then we would surely need to begin reducing our breeding herd here (July-August) or as early in the summer as possible either by selling off a larger than usual percentage of older breeding stock, or else by not keeping the usual number of replacement heifers or ewe lambs. For, if normal rain has not come by this time in midsummer, then we are seldom able to grow enough grass in the fall to make up for the earlier lack of forage production. To ignore this condition at this time is to invite abused ranges and the resulting excessive winter feed bills.

In our own ranch operation we have for years used a plan that has proved both profitable and beneficial to our range. About August 1 we take inventory of both our available forage supply and soil moisture and then accordingly we stock our range with short-term ewes that we own only about nine months. If we have received average or above average rainfall, we might purchase as many as 200 solid mouth ewes per section (about 5 years old in our area). However, in extended below average rainfall years, 100 per section, or less, might be all we could safely carry. We breed these ewes to Suffolk rams, lamb them in February, shear the ewes, market the lambs, and then market the ewes. Then we rest the entire range for about three months and repeat the cycle.

We market the lambs at 110-120 days of age without regard to condition of lambs or the market. Lambs are normally about at their peak at this age and time—and lambs, like watermelons, must be sold when they are ripe. This pactice allows us to market before the lambs need drenching, shearing their eyes, etc. These are significant savings. More important, by always trying to maintain our range in a healthy condition we are generally able to market top lambs at this early age and thus get them off both grass and ewes. Every day that these lamb units and the ewes, too, are off the grass is money in the bank. In fact, we have come to see alert marketing as one of the more important facets of conservation ranching.

Using this system over a period of years has allowed us to run more animal units of sheep per section than most of our neighbors. During 7 of the past 9 years we have fed no supplement and yet we have produced good percentages of lambs at good weights. We put the money that would otherwise have gone down the drain in feed bills into brush control and water utilization where it continues to pay dividends for years. We have been amazed to learn what can be accomplished with our low rainfall average when the moisture is efficiently utilized.

Now obviously not everyone can or would want to use the same system we use. At present, we are building up a cow herd that may come to comprise 25% of our base herd as a constant factor. Then we will evaluate the forage supply in August and adjust or fill out with short-term ewes in our usual practice.

Ranchers desiring to raise their own replacements might use a similar system and adjust their constant factor with larger or smaller numbers of breeding stock or by varying replacement numbers, etc. Obviously the rancher using only dry stock has his problem greatly simplified.

We were in a brush control program for many years, in a minor way. The first of this work we did, and much continues to be done, under the Agricultural Conservation Program in our area. But it was not until 1959 and 1960 that we came to fully recognize that brush, with its relentless spread, its greedy consumption of vital water and nutrients, and its other attendant problems, was far too costly for us to tolerate longer. So, in 1960, through the Soil Conservation District program, we worked out a comprehensive brush control and range management plan under the Great Plains Conservation Program with the technical assistance of the U.S. Soil Conservation Service. Since that time, we have done a complete renovation job by controlling all noxious brush by dozing with a front-mounted "stinger" on a bulldozer. Smaller woody and noxious plants, such as pricklypear and tasajillo, mostly have been hand grubbed. This was done on every acre of our 5,200-acre home place and was completed in 1964. The result has been an excellent recovery that we estimate to be a good 50% increase in productivity. We already have begun our plan to control noxious plant seedlings on a 5-year rotation cycle using a small D-4 "Cat." We plan to do some reseeding of native grasses, where needed, each time over in this rework.

In the summer of 1964 we acquired by inheritance an additional 1,800 acres of heavily brush-infested pasture in Coke County several miles from our home place. Since we had been so very pleased with the results of the Great Plains Conservation Program on our home place, the first thing we did was to work out a similar plan on this new operation, for it surely needed it. All forecasts were for above average rainfall in April, so we doubled up and did 2 years of

FIG. 5. This dense mat of nutritious sideoats grama and green sprangletop on the Skeete Ranch is the result of brush control, seeding and rest from grazing.

FIG. 6. This area formerly supported a dense stand of worthless brush with only a sparse cover of poor quality grasses and weeds.

our work plan in 1965 alone. The rainfall was good and we hit the jackpot. (Fig. 5 and 6.)

In recent years we have used the following precepts as guidelines toward more successful ranching:

1. Our basic production is grass and investments in improvement and restoration of grass are more important even than investments in improved breeding sires, or any other investment on the ranch.

2. Restoration of our present acreage is more practical than trying to purchase additional acreage.

3. Adjusting stocking rate to forage supply is basic to everything we do in planning.

4. This adjustment must necessarily be made before either range or stock suffer. We recognize that the range always suffers first and that it can happen before we detect it.

5. Above all, we do not want to get "married" to our livestock but rather to always keep at least a portion of this stock as expendables in critical drought periods.

6. Deferment is never a loss of forage—merely a period for increasing plant vigor and a forage supply for later use.

7. An orderly system of marketing stock is most urgent rather than continually trying to "out guess" the market.

8. There is no one poorer than a West Texas rancher who is always out of grass!

9. It is the rain you keep that counts; for unless we are efficient in this, we can't even hope to succeed in the others.

Brush control, maximum water utilization, deferred grazing, and proper range management by adjusting grazing to available forage, have all proved to be the most profitable and practical investments that we have ever made in the ranch business. Over the years, this has increased our productive capacity at a fraction of the cost of purchasing comparable additional acreage and without expanding costs of taxes and other fixed costs. For the usual range operation, our labor cost has been reduced a good 50%. Thanks also to the screwworm fly control program, our labor force is now more efficiently utilized. We have reduced or eliminated feed bills. Our production of wool and lamb has been consistently high. Obviously, we have invested considerable money for the size of our operation which is about average in our immediate locality. Yet, with the Great Plains Conservation Program cost-share assistance, these things have been accomplished and we are presently again operating on our own capital. Here, it seems to me, is the most practical approach to coping with the ever mounting cost of supplies, labor and taxes, and the competition of foreign meats and wool.

In closing, I want to say that the Great Plains Conservation Program with both the cost-share assistance and the technical assistance in comprehensive planning has proved, in my opinion, to be the finest educational tool that we have ever had in the field of conservation education. For here is indeed a very valuable tool that enables us to implement the very best educational, research and technical services of *all* our agencies, both State and Federal. To each of you agency people, educators, and research people, we say thank you for the services you have contributed to make our own work possible, and we hope that we will yet accomplish the level of conservation that you and I know is possible, if we ranchers will just diligently apply even the best knowledge and research presently available.

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Drylot Wintering of Range Cows—Adaptation to the Ranching Operation

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Highlight

Pregnant range beef cows adjusted to drylotting on all-concentrate grain sorghum rations and then readjusted to native range. Weight changes and reproductive performance on a limited all-concentrate ration compared favorably with commonly used methods of wintering the cow herd. Costs for two drylot methods were higher than for two pasturage methods.

The progressive rancher always looks for ways to cut cost without reducing production. He also looks for ways to improve his range. Drylotting offers one way of doing both. Recent work on drylotting with silage (Marion et al., 1965) and with all-concentrate rations (Thomas and Durham, 1964) indicates the possibility of integrating either of these drylot techniques into the ranching operation.

In a five-year study, Marion et al. (1965) found that drylotting a cow herd with sorghum silage and grain compared favorably with maintaining a cow herd on native range throughout the year. Their studies suggest that drylotting can be successfully integrated into the ranching operation to increase ranch production without increasing ranch size.

Thomas and Durham (1964) reported studies which show distinct advantages of limited feeding of all-concentrate rations for cattle maintenance. They pointed out possibilities of integrating all-concentrate feeding into the ranching operation, the need for further study of all-concentrate feeding, and its place in ranching operations.

The cost of grains is often such that net energy obtained per dollar spent for concentrate feed, such as sorghum grain or corn, may be greater than for roughage. Ellis (1965) reviewed recent developments in the use of all-concentrate rations in commercial feedlots. The pros and cons of all-concentrate feeding are about evenly divided, and in the final analysis economic factors will determine whether roughages or concentrates should be used. When local surpluses of grains occur, maintenance rations of concentrates may be cheaper than roughage rations. Too, the ease of handling and transporting concentrated feedstuffs give them a distinct advantage for isolated ranches. Because of these factors, more information is needed on the adaptability of range cattle to all-concentrate feeding.

This study was designed to determine whether pregnant beef cows could be wintered successfully on limited all-concentrate rations and whether they could readjust back to the native range environment. The drylot technique was compared with commonly used methods of wintering the brood cow herd.

Procedures

The study was initiated on November 30, 1964 on the Edwin Forrest Ranch, Slaton, Texas. The 144 grade Hereford cows used for the study were maintained on a sorghum *(Sorghum vulgare* Pers.) stubblefield for 45 days prior to beginning the study. After an overnight shrink the cattle were weighed, tagged individually, and randomly separated into four groups of 36 each.

The following feeding treatments were established:

1. Pasturing on native range supplemented with 1.0 lb. of 20% protein range cubes per head daily (native range).
2. Pasturing on a combination of sorghum stubble and wheatfield (stubble-wheatfield).
3. Drylotting on sorghum silage supplemented with 0.75 lb. sorghum grain and 0.75 lb./head/day cottonseed meal (silage).
4. Drylotting on an all-concentrate ration (all-concentrate).

Under the native range treatment the cattle had access to 640 acres of native range. In addition, they were fed 1.0 lb. of 20% range cubes per head per day, plus free choice of salt and mineral supplement.

The cattle on the stubble-wheatfield treatment had access to sorghum stubble from December 1, 1964 to January 7, 1965 and green wheatfields from January 7 to March 26, 1965. A salt and mineral supplement was provided free choice.

The silage ration consisted of free choice sorghum silage plus 0.75 lb. sorghum grain and 0.75 lb./head/day cottonseed meal. The feeding for this treatment was contracted to a local feeder. After the first 60 days chopped hay (about 30% of the ration) was included in the ration to decrease milk production of the cows and in turn, prevent scouring of the newly born calves.

The all-concentrate ration consisted of 82.5% irrigated-sorghum grain, 7.5% cottonseed meal, 5% dehydrated alfalfa, and 5% premix. The premix contained enough vitamin E to furnish three international units (I.U.)/lb. of ration; enough vitamin A to yield 70,000 I.U./head daily; vitamin D 9,000 I.U.; Aureomycin 70 mg.; and salt 0.11 lb., on a 9 lb./day ration.

After two weeks, two cows were removed from the all-concentrate treatment because they did not adjust to the ration and total feed increased to 9.5 lb./head/day of all-concentrate ration. After calving began, 2 lb. of whole cottonseed were added to the daily ration for each cow to provide an extra source of fat for the lactating cows. Increasing fat content of the all-concentrate ration had been observed to increase calf livability.[1] The calves were creep-fed alfalfa hay and a mineral-salt mix.

Sampling of the feedstuff for all treatments was conducted during the feeding period. At the conclusion

[1] *Durham, R. M. 1965. Unpublished data. Texas Technological College, Lubbock.*

of the feeding period on March 26, 1965 (116 days), all cows were weighed individually and placed on native range for the summer grazing period. Bulls were introduced on April 1 for 90 days. At weaning, November 29, 1965, all cows were weighed individually and checked for pregnancy.

We wish to express our thanks to the Grain Sorghum Producers Association, Amarillo, Texas, for contributing the sorghum grain; to Wilbur-Ellis Company, Lubbock, Texas, for supplying the ration premix; and to Mr. Edwin Forrest, Lubbock, for use of his ranch facilities, cattle and feed for all except the all-concentrate ration. Thanks are also due to G. W. Thomas, Dean of Agriculture; to R. M. Durham, Professor of Animal Husbandry; and to T. W. Box, Professor of Range Management, for their invaluable guidance and assistance.

Results and Discussion

The chemical contents of the feedstuffs used in the study were considered average for the South Plains region (Table 1). The 640-acre native range pasture was about half sandy-upland site and half sandy-bottomland site. The principal species on the sandy upland site were bluegrama (*Bouteloua curtipendula* (Michx.) Torr.), buffalograss (*Buchloe dactyloides* (Nutt.) Engelm.) and threeawns (*Aristida* spp.), sand sagebrush (*Artemisia filifolia* Torr.) and honey mesquite (*Prosopis glandulosa* Torr.) were the principal woody species. The sandy bottomland site supported primarily alkali sacaton (*Sporobolus airoides* (Torr.) Torr.), inland saltgrass (*Distichlis stricta* (Torr.) Rydb.) and switchgrass (*Panicum virgatum* L.). Range condition ratings were fair for both sites.

Adjustment to the rations.— The native range treatment was the normal wintering procedure for beef cattle on the Forrest Ranch. Grazing was confined to the sandy upland site initially with the cattle gradually using the sandy bottomland site toward the end of December (Fig. 1).

Table 1. Average chemical composition (percent) of various feedstuffs during the 116 day wintering period.

	Analysis			
Feedstuff	Dry Matter	Crude Protein	Ether Extract	Ash
Stubble-wheatfield:				
Sorghum stubble[1]	96.9	4.2	1.0	10.6
Sorghum heads, threshed	95.0	5.7	0.7	8.7
Wheat forage[2]	30.9	19.3	3.8	8.7
Native range:[1]				
Sand sagebrush	94.9	6.7	6.7	3.4
Switchgrass	95.9	1.7	0.6	5.8
Inland saltgrass	95.8	4.8	0.9	7.3
Threeawns	96.3	3.6	0.8	6.1
Blue grama	95.7	4.6	0.8	8.3
Alkali sacaton	96.0	4.2	1.2	6.8
Range cubes	93.1	23.7	5.3	5.6
All-concentrate:				
Alfalfa meal,[3] dehydrated	93.5	16.9	2.6	10.0
Cottonseed, whole	93.2	19.4	19.0	2.5
All-concentrate ration, composite	91.0	11.2	2.8	6.9
Silage:				
Sorghum silage[4]	29.6	1.7	0.5	0.8
Cottonseed meal	91.2	41.6	5.9	6.2
Sorghum grain, medium cracked	89.3	9.5	3.2	2.3

[1]Sampled December 7-10, 1964.
[2]Sampled January 7, 1964.
[3]52,200 micrograms carotene/lb., equivalent to 86,700 I.U. of vitamin A/lb.
[4]Average of biweekly samples.

No particular problems occurred in this treatment through the feeding period. It was considered the basis of comparison for the other wintering methods.

The 42-acre sorghum field had been harvested in early September. Considerable grain remained on the discarded heads. The irrigated wheat, planted in the fall, had made good growth and averaged 4-inch leaf length at the beginning of the study (Fig. 1). Adjustment to the sorghum stubble and wheat was normal except for two mild cases of wheat poisoning on March 22. All cattle were then moved to an adjacent native range for the last four days of the feeding period.

Although a change in environment — even a simple change from native range to cultivated pasturage — affects cattle performance, such changes must be considered part of a normal ranching operation. The change from native range to confinement in a drylot is, however, more drastic and must be considered in the evaluation of drylot operations. Physiological and sociological problems become more pronounced in confinement and tend to influence cattle performance.

Some difficulty was noted in the adjustment of the silage group. There was an evident loss of weight during the first few days of confinement. Within two weeks, however, the cattle appeared well adjusted to the confinement and ration (Fig. 1). Their original condition was regained rapidly.

Adjustment problems were encountered on the all-concentrate treatment at the beginning of the trial. All cows appeared to

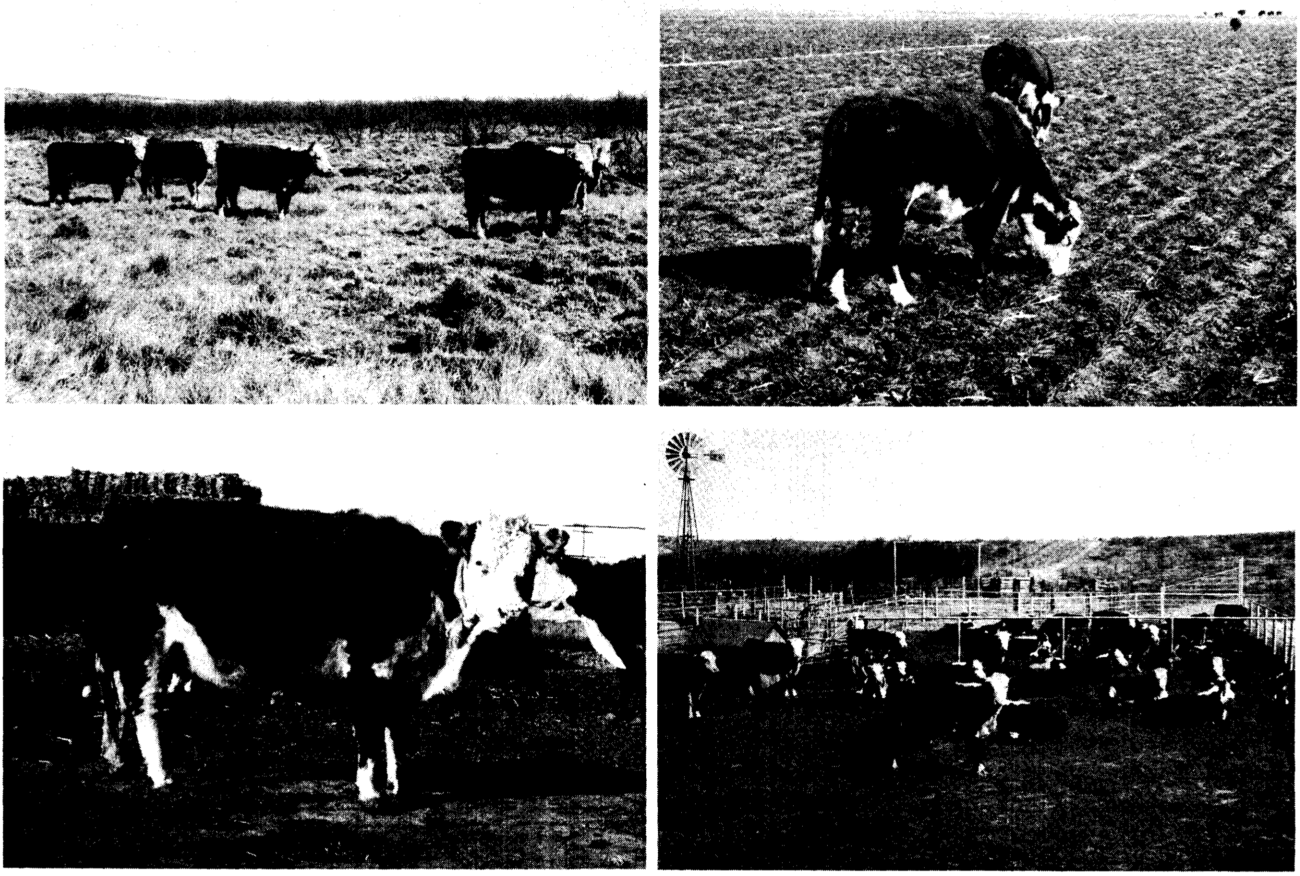

FIG. 1. *Upper left*—Cows wintering on native range. Bottomland site in foreground and sandy upland in background. *Upper right*—The cows were in good flesh when turned onto wheat after 38 days on sorghum stubble. *Lower left*—The cows were well adapted and in good flesh after 90 days on silage. *Lower right*—After about two weeks, the cows appeared adjusted to the all-concentrate ration and confinement.

lose weight at first, but initial adjustments seemed satisfactory. By the second week, however, two cows were removed because they were definitely not adjusting to the all-concentrate ration. The remaining cows had no difficulty in adjusting to the all-concentrate ration (Fig. 1).

Some of the difficulty in adjusting to the ration may be attributable to the confinement to small areas. Some range cattle are naturally nervous and will not adjust to any type of confinement. Also, those that are timid are usually the weaker cows and are pushed away from feed by the stronger cattle. They consequently get less and less of the ration, whereas the stronger cows keep getting more. This phenomenon was observed.

It has also been reported that fattening cattle consuming rations with high amounts of sorghum grain will sometimes "go stale" (Cardon, 1965). The exact phenomenon of this is not known, but it may be due to changes in the rumen and the activity of the rumen bacteria. Or, it could be due to the grain itself, its physical condition or digestibility. This phenomenon was not noted during these trials, but the animals were limited to only 7.8 lb./day of sorghum grain.

Observations from this and other studies at Texas Tech suggest that approximately 10% of the cows placed on the all-concentrate ration will not adjust to the ration and/or confinement and should be removed from the ration. Good management and close observation of the cows during the initial two weeks is essential. Those animals not eating or showing evidence of social problems should be removed.

Reproductive performance. — Calving began during the first month but did not reach its peak until near the end of the wintering period. Calving was irregular and incomplete at the end of the wintering period; thus, no inferences can be made as to the effects of the various wintering methods upon calving percentages and weights. However, there was no calving difficulty in any of the groups.

All cows of the native range and stubble-wheatfield groups were pregnant at weaning time (Fig. 2). On the other hand, only 81% of the silage group and 90%

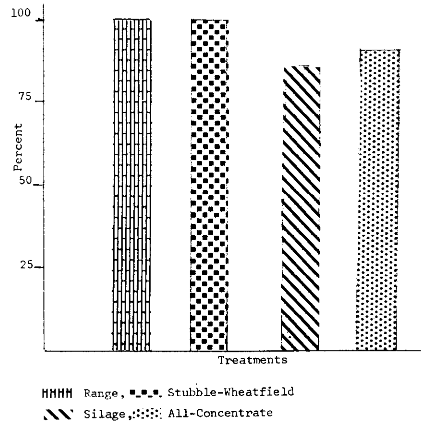

FIG. 2. Percentage of the cows on each treatment pregnant at weaning time, November 29, 1965.

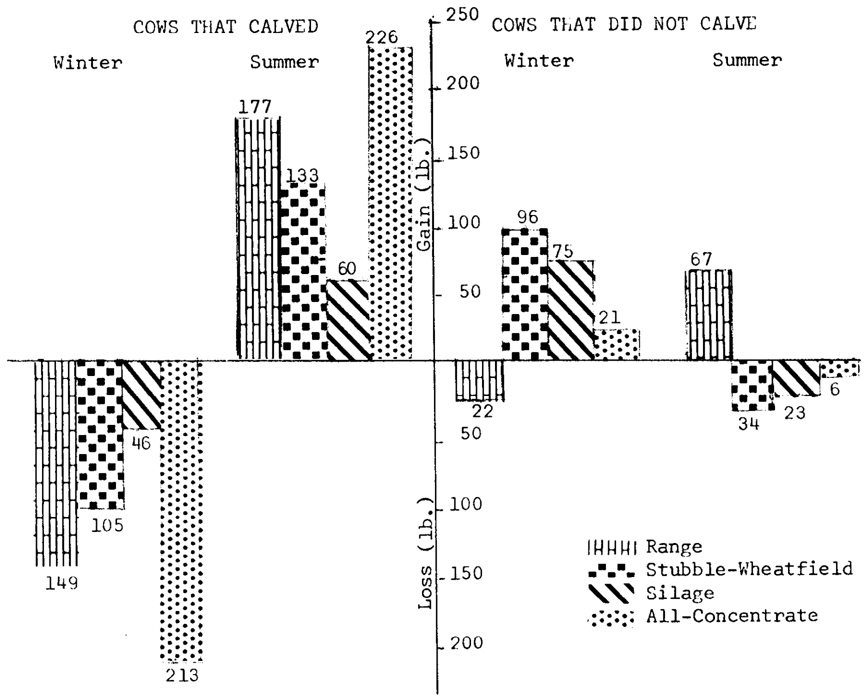

FIG. 3. Average weight changes of cows during winter feeding and summer grazing periods.

of those on all-concentrate were pregnant. Although not statistically significant (P>.05), these differences suggest some reproductive difficulties attributable to drylot treatments.

The lower conception rate of both drylot groups might be attributed to their low level of nutrition at the beginning of the breeding season which began five days after wintering period ended. Cattle from the silage group were in best flesh at the end of wintering period, but were observed to show stress and loss in weight for about two weeks after returning to native range. On the other hand, cattle from the all-concentrate group started the breeding season in low level of nutrition, but were observed to gain weight and improve their general condition rapidly upon being put back on native range. We feel that both the initial low level of nutrition of the all-concentrate group and the period of stress shown by silage group brought about the lower conception rates in these treatments.

Weight changes. — Cows not calving during the wintering period lost significantly (P<.05) less weight than those calving. Weight changes of the dry cows will not be discussed since the degree of their fetal development was not known at the end of the wintering period.

Of the cows that calved during the wintering period those in the silage group lost significantly (P<.01) less weight than the other groups (Fig. 3). Weight losses by those on native range were similar to losses of the all-concentrate group. Both of these groups lost significantly more than the others. These losses are not considered excessive, however, since winter losses on native range in this region often exceed 200 lb. (Marion et al., 1965). Losses on the stubble-wheatfield were intermediate. Both dry and lactating cows apparently did better on silage than on the other rations.

Gains during the summer period were directly proportional to losses during the preceding winter period for all groups (Fig. 3). Cows with calves born in the all-concentrate groups averaged losing 213 lb. during the 116-day wintering period and gained 226 lb. during the following summer grazing period. In comparison, cows calving on the silage treatment lost only 46 lb. during the wintering period, but gained only 60 lb. during the summer period.

The cattle maintained themselves on the limited ration of 9.5 lb. of all-concentrate until calving. After parturition, however, it was evident that the limited ration was not enough for a cow with her suckling calf. The cows with calves appeared to lose weight steadily to the end of the feeding period even though an additional 2 lb. of cottonseed were added to the ration when calving began. The difference in condition between those cows just calving and those having older calves was evident (Fig. 4). Under ranch conditions, cows should be removed from the limited all-concentrate ration after calving and provided a higher intake of energy.

As a consequence of the weight loss during the wintering period and gain during the summer period, weights at the beginning and end of the study were not statistically different (Fig. 5). All groups weighed slightly more at the end of the summer grazing period than at the beginning of the study a year earlier.

Costs. — Actual costs incurred

FIG. 4. Cows did well until calving but lost weight steadily on 11.5 lb. all-concentrate ration after calving. The cow on the left had a two-day old calf; the one on the right, a two-month old calf.

during the study were used to determine treatment costs to show influences of local conditions. The stubble-wheatfield was contracted at $3.50/A.U.M., averaging $0.12/head/day. The silage feeding was contracted to a local feeder for $9.00/A.U.M. or an average of $0.30/head/day. Both of these treatment costs included management and all feedstuffs except mineral supplement for the stubble-wheatfield group. Use of home-grown and fed silage would undoubtedly lower feed costs for the silage ration. For example, if silage could be grown and fed for $8.00/ton and 40 lb/head/day were required, the 30-day cost would be $4.80. Adding a cost of $0.015 for 0.75 lb./day sorghum grain and $0.03 for 0.75 lb. cottonseed meal, the total feed cost would be $6.15 per month ($0.21/head/day).

Brood cows have been maintained continuously for five years at the Spur Experiment Station, Spur, Texas, on 40 lb. silage, 0.75 lb. cottonseed meal, and 2 lb. sorghum grain for an average feed cost of $6.33/head/-month or slightly over $0.21/-head/day (Marion et al., 1965).

Feedstuffs in the all-concentrate ration at local prices totalled $0.28/head/day. This includes the addition of 2 lb./-head/day whole cottonseed after calving began, but did not include feeding labor cost. Again, a change in price of the feedstuffs, especially the grain, would change the total cost. For example, grain used for this study cost $1.97/cwt. Had the 1964 average price for sorghum grain ($1.73/cwt.) in Texas (Crop and Livestock Reporting Service, U.S.D.A. 1965) been used, the cost for the all-concentrate ration would have been $0.26 rather than $0.28/head/day.

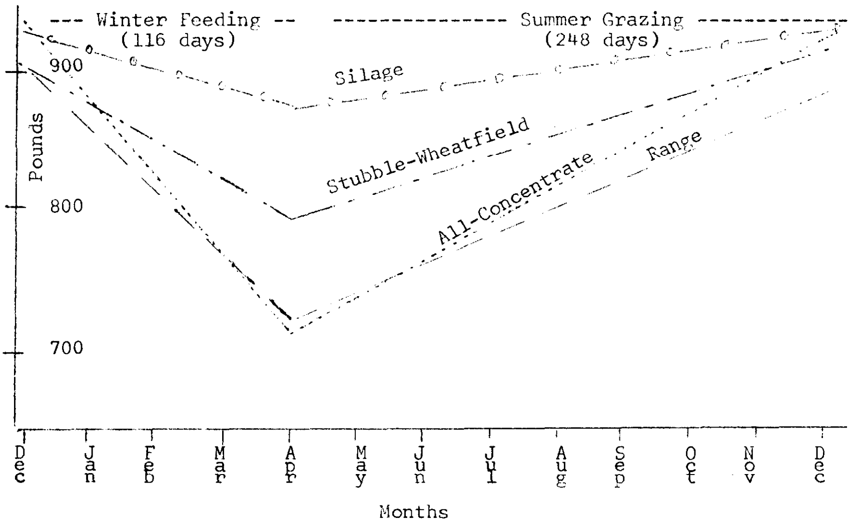

FIG. 5. Average weights and weight changes of cows that calved during the wintering period.

An average cost of $0.16/-head/day for native range included a charge of $4.00/A.U.M. grazing fee plus a cost of $.026/-head/day for 1.0 lb./day range cube supplement.

Summary

Grade Hereford cows were wintered by four different methods. The methods were native range, sorghum stubble-wheatfield, drylotting on silage, and drylotting on all-concentrates. The cattle were wintered for 116 days in their respective treatments, then turned back on native range. Primary concern was the ability of range cattle to adjust to the all-concentrate ration and to readjust back to native range environment. The reactions of the cattle on the native

range were considered normal and used as a basis for comparison of the other three treatments.

Some difficulty in adjusting to the drylot was noted in both the silage and the all-concentrate groups. After the first two weeks, however, very few problems were encountered in any of the treatments.

About half of the cows calved during the wintering period. Of the cows that calved, those on the silage group lost significantly less weight than the other groups. Those on the native range and the all-concentrate ration lost similar amounts, and both of these groups lost significantly more weight during the wintering period than the two pasturage groups. Weight gains during the summer grazing period were directly proportional to weight losses during the winter period.

Cattle on the all-concentrate ration did well until calving. After parturition, however, the cows lost weight steadily until the end of the feeding period. It was concluded that the cows that calved on limited all-concentrate rations should have been removed and provided with a higher intake of energy.

Only the silage group were observed to lose weight in adjusting back to the native range pasture. This period of stress at the beginning of the breeding period apparently brought about a lower conception rate in this group of cattle.

Costs of the wintering period favored the pasturage methods with the stubble-wheatfield method being the cheapest. Average costs during the winter period were: range—16¢, stubble-wheatfield — 12¢, silage — 30¢, and all-concentrate — 28¢/head/day.

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How To Get A Bandwagon Going[1]

JIM WILSON
Wilson Seed Farms, Polk, Nebraska

Highlight

A well-known native-grass seed producer tells how eastern Nebraska farmers and ranchers were inspired to help roll back the frontier of grass-planting knowledge in a unique and highly imaginative "do-it-yourself" grass experiment-and-education program.

"What do I want with your gol-dang bulletins? I ain't doin' half as good as I know how, as it is!"

It's an old joke about a problem as old as agricultural science itself. How can we get the land-user to do as well as he knows how, and learn to do still better? Hold more meetings and tours? Produce more radio and TV programs? Write more magazine articles and bulletins? Centralize the Information Service? Decentralize the Information Service? Replace the Coordinator with a Director, or vice versa? Overhaul the whole system?

No, the system itself is all right. Almost any system will work, if it's well spiked with imagination. That's what we're short on.

Many college-trained professionals drift into the habit of depending on well-worn academic clichés of thought and expression, instead of thinking creatively. However, you can't spread the Gospel by rote. Every successful speech, magazine article or information program is a unique, one-of-a-kind symphony of ideas dreamed up by some imaginative fence-jumper who has learned to soar above the dull world of set patterns and procedures and "play it by ear".

In 1956, after half a lifetime as a travel writer, lecturer, and college teacher, I retired with my wife to one of our farms near the town of Polk, in east central Nebraska, and we began to produce native grass seed (Fig. 1). As landowners in two states, we'd been interested in conservation for many years, and had written several articles on the subject.

This was new territory for native grass. Most of the land-users weren't ranchers, but farmers, brought up in the tradition of cultivated crops, many of them churning hill land to death in money-losing tillage because they didn't know what else to do with it.

All they knew about native grass was that you couldn't afford to plant it, because it "took five years to get a stand." Not even the Soil Conservation Service nor the College could depend on getting good stands of big bluestem, indiangrass, switch-

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[1] *Based on a paper presented at the Annual Meeting, American Society of Range Management, New Orleans, Louisiana, February 1 to 4, 1966.*

grass and sideoats grama consistently in eastern Nebraska. Too many features of the grass-planting technology developed for the western Great Plains didn't work on the fertile, high-rainfall, weed-infested cropland of the Corn Belt.

We couldn't sell our seed, because nobody had the know-how to use it. But our Work Unit Conservationist, Harold Klingman, was sure we could learn to make native grass competitive with cultivated crops in eastern Nebraska.

We couldn't wait for the College to learn through research and tell us. They were desperately short on money and manpower, and anyway, the wheels of formal research turn pretty slowly, because everything has to go through Committee! As private enterprizers, we weren't handicapped that way.

Operation Bootstrap

So we invented "Operation Bootstrap". It wasn't an organization. It was just a name for a way to get land-users steamed up to experiment with new ideas—to take some of the load off the overburdened research agencies and find out a few things for themselves.

To most farmers and ranchers, applied grass research is strictly a spectator sport. Only academic professionals are actually allowed on the playing field. When the game is over, the professionals announce the result in an impressive bulletin or article—often in form and language more suitable for other professionals than for land-users—and the land-users, having had nothing to do with the project up to this time, are expected to climb right up on the strange new bandwagon and drive off with it. When they don't, the professionals are baffled and disappointed.

We tried a different tack. We got the land-users out on the playing field right at the start. We had to. There were so many things to be learned that our only hope was to enlist hordes of troops and attack on all fronts.

As the project developed, it was like putting together the pieces of a

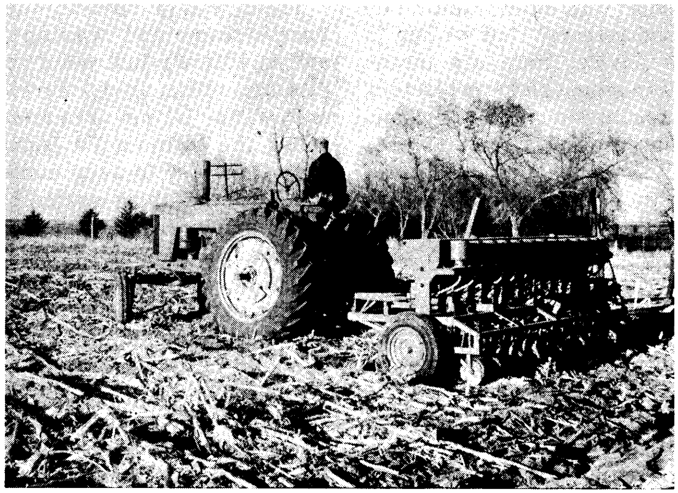

FIG. 1. Jim Wilson planting indiangrass with Nisbit grass drill in last year's irrigated corn field.

jigsaw puzzle. It took a lot of imagination to see how the scattered pieces fitted together. It takes imagination to assemble the ideas that make up *any* promotional campaign, magazine article, speech or bulletin, put them together and present them in such a way as to get men to *act*. Without imagination, the man who works with ideas is rattling dry bones.

What *is* imagination? Can you acquire it, if you don't have much to start with? Can you learn creative thinking? Certainly.

How does a creative person invent a new idea in communication, in research, in *anything*? You do it the same way you put a jigsaw puzzle together—by dredging up seemingly unrelated ideas at random and trying them out in relation to each other until you find two or more that fit together.

In England 200 years ago, there was a need to pump water out of flooded coal mines faster than a donkey could do it. We've known about the crank for many hundred years. Kids have made popguns almost as long. Blacksmiths have had one-way valves in bellows even longer. And steam has blown lids off teakettles since man has had teakettles. Attach a steam popgun with valves to a crank and what do you have but a steam engine?

Col. Drake discovered petroleum at Titusville, Pennsylvania, in 1859; man tried kerosene in the old whale-oil lamp, and it worked. There was a by-product so explosive as to be useless. It was called gasoline. In the meantime, Faraday—by the same simple process of random fitting together and testing of apparently unrelated ideas—had come up with the electric spark coil. Take the steam out of the old steam-engine puzzle picture and try replacing it with gasoline and an electric spark. What would life be like today without the internal combustion engine?

The Chinese were flying kites 5,000 years ago. Two thousand years ago the Greeks amused themselves with toy propellors that rose through the air when spun between the hands. The Wright brothers perceived the natural affinity between these two ideas and the internal combustion engine, and today we fly through the air with the greatest of ease.

Now for an example closer home, in the field of agricultural communication. Let's round up the scattered pieces of the eastern Nebraska native-grass jigsaw puzzle.

Here is a seed producer who needs more know-how in order to sell his seed and stay in business. Here are thousands of land-users who need the same know-how in order to use the grass seed to conquer erosion, produce more beef, make more money, and get more satisfaction out of life. These land-users have the universal human urge for fun, excitement, drama and adventure—anything to make life more interesting—and they have land, equipment, time, and money with which to experiment. Here are the SCS and the

College, short on money and men for tests and research, but willing to help with advice. Here are magazines, newspapers, slide projectors, mimeographs, radio and TV, organizations that use speeches and programs—all the modern media of communication. And here is a whole world of ideas about grass-planting floating around in thin air, in people's minds, in Nature, waiting to be tried. Surely these elements all fit together just as beautifully as the kite, the propellor and the internal combustion engine.

The first thing was to whet the land-users' interest and get them talking about the Wilson Seed Farm and buying seed to experiment with.

We had a good dramatic human-interest story about a couple, retired in their fifties, who weren't content to spend the rest of their lives playing shuffleboard in Florida, but came out to an unimproved Nebraska dry-land farm, leveled it for irrigation themselves while living in a trailer in the weeds and clods, learned to farm it, and now, unwilling to join the crowd raising surplus corn and milo, were doggedly learning how to plant grass the hard way — by making all the mistakes ever dreamed of, and then some!

And we had slides to go with the story. Not just dull, earthbound "shots for the record" — that isn't enough. Beautiful, soaring, emotionally charged scenes that lifted the heart while they informed the mind. My wife is a terrific photographer.

There was a spot in the jigsaw puzzle ready and waiting for that story. I didn't just point to a slide and say, "This is our leveling outfit," "This is our irrigation well." Using the formula I'd learned as a travel lecturer to keep audiences on the edge of their seats, I welded slides and narrative together into a smooth, fast-moving adventure story, complete with suspense, plot, obstacles, struggles and set-backs, progress and triumph (Fig. 2). As our seed customers, friends and advisors joined us in the search for answers to our mutual problems, I wrote them into the story to keep it up to date, portraying the characters in such a way that my audiences would identify with them in their quest and try the ideas themselves.

The theory of such a speech is the same as that behind popular newspaper and magazine writing for educational purposes. Don't expound abstract ideas. To most people, they simply aren't real. Make a *story* out of your story. Use illustrations, examples, anecdotes, snatches of conversation, showing how these ideas work out in real life. People like to hear about other people doing real things in a real world.

We had to advertise in the local papers to get their cooperation. However, display ads are expensive and people don't pay much attention to them. Everyone reads the want ads, though. Ever notice how you turn to the "Personal" column, hoping for a smile or an oddity of some kind? Testimonials!

We started with this one:

"Wilson Seed Farm. Dear Sir: I planted yur switchgrass. It growed so tall my cows couldn't reach it. I traded my cows for giraffes. We git six litters a year. You know anybody got half a hog to trade for 300 giraffes? My wife and me are gittin' awful sick of giraffeburgers. Yogi Yorgensen."

We went on to match up well-known characters of all kinds with the idea of Grass and its many variations, looking for humorous relationships between them:

"Wilson's Pawnee Big Bluestem make heap good pasture. Maybe buffalo come back now. Sitting Bull."

"Confucius say: Wilson's Reed Canarygrass velly good for chop suey."

"Dear Isabella: Discovered New World today. Impenetrable forest of Wilson's Holt Indiangrass prevents landing. Cable instructions. Love. Chris."

This was the bait that got land-users coming to the Wilson Seed Farm, first by tens, then by hundreds, to see if that crazy guy might just accidentally be crazy like a fox. They usually left with a load of grass seed and a jugful of new ideas, eager to help us push back the frontier of Corn-Belt grass-planting technology by experimenting on a few acres.

The local papers in which we advertised were glad to run thumbnail stories about grass every week, because we always made them imaginative, fresh and readable — like these two:

FIG. 2. Seed producer Jim Wilson shows off his Holt indiangrass field. Photo by Roy Alleman, The Farmer Stockman, Cozad, Nebraska.

FIG. 3. Leroy and Mrs. Nelson, SCS Work Unit Conservationist Harold Klingman, and Jim Wilson in Roy's 2-year old irrigated native-grass row pasture.

Nebraska's Floating Away Again

Time for the early morning news. We turned on the radio and the familiar voice of Dutch Woodward filled the room. This time it wasn't the disarmament talks, Jackie's trip, the perennial hassle over the State Game Department, the unsuccessful burglar who got tossed in the clink —the same old news that's always different, yet always the same.

This morning, the really BIG STORY was that Dutch's wife had just come out from Omaha on U. P. number 27, and it was the last train to get through before the tracks were washed out.

The morning paper filled in the picture — helicopters hovering over drowned farms and valleys, families being evacuated to West Point and Beemer, the Elkhorn three feet above flood stage, highways 30 and 275 closed—complete with photos of farms under water and boats in Main Street.

Once again, Nebraska was floating away, and with it were millions of dollars invested in farm land. When the country dries off—new gullies, new mud flats, new patches of buckskin on hillsides to bake and crack in the sun.

Where did the floods start? On that rough, rolly-coaster field that your granddad plowed up in World War I and you've been losing money on ever since.

What can you do about it? Join Operation Bootstrap. PLANT GRASS.

Native Grass No Good For Milk Cows

It isn't any fun to have to admit a mistake. But if we didn't tell you the bad, along with the good, you'd soon lose confidence in Operation Bootstrap. We therefore feel honor-bound to report the unfortunate experience of Leroy Nelson, who lives two miles west of Polk.

Roy has 4½ acres of irrigated native-grass pasture in two plots, planted three years ago. So far this season, these two little pastures have provided rotation grazing for 14 cows and four calves for almost seven weeks, and the grass is going to seed for lack of sufficient use (Fig. 3).

However, Roy says native grass is no good for milk cows. You have to buy too many milk cans. It runs the expense up too high.

These little sketches reflect that simple imaginative process of matching up apparently unrelated ideas till you find a combination that clicks.

I blew the grass bugle in regional and national farm magazines the same way, except that the articles were longer and contained a bigger pill within the sugar coating. I never wrote an "Introduction" to an article. Instead, I wrote an exciting, arresting *beginning,* that swept the reader directly into the flow of the story in spite of himself. If you can get a good, high-voltage beginning, the rest of the article will almost write itself.

Years ago, an SCS friend showed me a story on grass he was trying to write for a local paper. It began like this:

"Grass has become one of the most stimulating and motivating forces in getting farmers interested in Soil Conservation in northeastern Colorado. Through this interest, the door has been opened to a more significant interest in dealing with some of the more critical soil conservation problems which exist on most every farm and ranch." Now who's going to read that?

I gave him a copy of a speech on "How to Write Agricultural News and Feature Stories" which I'd made at a conference of District Conservationists. Next week he came back with this:

"'You guys are poor salesmen,' rancher Harvey Harris told me. 'Why do you tell a man to plant grass only on his poorest land? I plant it on the best land I've got!'

"Rancher Harris has plenty of proof that grass is a money-making crop on the very best land. So have Everett Barden, Gordie Knode and Bill Oliver." And the article went on to give the proof in a lively series of anecdotes, each illustrating a different angle of the idea. Every farmer and rancher in the area read that story about what his neighbors were doing and talked about it for weeks afterward. Many infidels were brought to the True Faith.

To go back to Operation Bootstrap, soon we were ladling out seed right and left, and ideas to go along with it. Whenever a customer turned up, we'd invite him to live dangerously on a few acres.

"We don't any of us know much about this business," we'd say, "and we've all got to learn. How about helping? I have a hunch cool and warm-season grasses will do well together. Want to try it?" Or, 'Here's a new idea for licking the grassy weeds in new stands. Let us know how it works."

Quickly the news spread that something new and exciting was happening. Within a year, land-users all over the area were champing at the bit to get in on the thrill of experiment and discovery. Whenever we turned up a new idea from any source—the SCS, the College, other farmers, or dreaming it up out of thin air by the process of imaginative thinking—we had a dozen communicants camped on our doorstep, eager to try it. Within five years we had, I am sure, more different kinds of experimental pasture plantings within a 100-mile radius of our seed farm than you could find anywhere else in the United States—dozens of each kind. Today, more than a thousand land-users are helping us learn the things we all need to know.

It isn't "research", of course. We don't turn out scientific papers with tables and charts. With so many urgent problems to be coped with at once, we'd be licked at the start, if we took time for meticulous techniques.

We depend instead on mass experience and observation. We think that when a hundred or more land-users all try the same idea under different conditions and toss their experiences and opinions into a central hopper, what comes out at the bottom is likely to be as good a guide as the conclusion drawn from one meticulously conducted piece of research under one set of conditions on replicated table-size plots. It's a different kind of hunting—we shoot with a shotgun, not a rifle—but we bring down a lot of birds!

We've learned to get good native-grass stands the first year on rich soil infested with grassy-weed seed. We've learned that you can plant native grass in eastern Nebraska clear up to late July or early August most years. We pioneered the planting and correct management of "all-season" pastures — a mixture of warm-season natives plus a sprinkling of cool-season grass — on both dry and irrigated land (Fig. 4). Our great interest in this innovation is based on the experience of 386 cooperators whom we've persuaded to try it.

We pioneered the planting of irrigated pasture in cultivated rows on land with too much cross-slope to border and flood. We pioneered the planting of reed canarygrass for irrigation in Nebraska. We've learned that we can move most of the present varietal recommendations for warm-season native grasses up to 100 miles north on dry land, still farther on irrigated.

We've learned to get good stands of birdsfoot trefoil with native grass in Nebraska. Now we're experimenting with crownvetch. And we're even getting eastern Nebraska pasture-users converted to the gospel of "take half, leave half," believe it or not!

As our cooperators began to report how their experimental plantings were turning out, we sent out questionnaires, made inspection trips to see for ourselves, and passed the word along, through speeches and slide-programs, tours, magazine articles, breezy mimeographed handouts, and by word of mouth personally. More and more, my thumbnail sketches for the local papers became success and how-to-do stories:

Seeing Is Believing

"It takes five years to get a good stand of native warm-season grasses," declared a Kansas man on the Operation Bootstrap tour two weeks ago. "I've done it, and I know."

"Maybe so, the way you do it in Kansas," said Elmer Allinder, "but not in Operation Bootstrap territory. Here it takes just a year."

On the Allinder farm southeast of Osceola the Kansas man saw the proof.

Go and see for yourself. Ask Elmer to show you his native-grass planting made last year in May—just 14 months ago. The grass is as thick as a carpet and as tall as a car. It's that cool, fresh, live green that's the most beautiful color in the world. This is what the Tall Grass Prairie looked like before the white man plowed it up or ruined it by over-grazing.

Look at the threadbare weed-and-bluegrass-infested native pastures along the Platte River. Then look at Elmer's planted grass. Now you can see why the SCS says the carrying capacity of old "grazed-out" native-grass pastures can be increased up to 500% by getting rid of the junk and planting improved strains of good grass. It can be done in about 18 months. If you want to know how, ask Operation Bootstrap.

Often we created news by putting together several elements in a situation in such a way as to benefit everyone concerned. One summer, to get information on fertilizing grass, we toggled up a mechanical plot-clipper out of an old sickle-type power lawnmower and had high-school science students make clip tests on demonstration plots put out by the Extension Service with free fertilizer provided by a company in exchange for publicity (Fig. 5). Result: a fine magazine article, good experience for the students, more profit for land-users, increased fertilizer sales by the company, publicity for Operation Bootstrap, good will for the Wilson Seed Farm, and stars in everyone's crown. All things work together for the good of them that use their imaginations to put jigsaw puzzles together!

What has amazed and delighted us is the effect all this has had, not only on the land itself, but on the participating land-users. It makes 'em feel like astronauts—even those who were farming only because they'd had the misfortune to inherit the land and hadn't known how to escape from it.

It's given them a new vision of themselves and their relationship to the land on which they live and make a living. Imaginations that have lain dormant for decades light

FIG. 4. SCS State Agronomist E. O. Peterson displays Harold Beck's all-season planting of intermediate wheatgrass, switch, indian, sand love, and big bluestem grasses and alsike clover. SCS Photo.

FIG. 5. Bootstrap Junior Scientists Galen Sterner, Kendall Sandell, and John Recknor make clip tests on fertilized Holt indiangrass.

up like Christmas trees and infuse new meaning into lives that have been drab and inconsequential. And we have probably learned in six years as much about planting and managing grass in eastern Nebraska as we would have learned in fifty, had we waited for the wheels of conventional research to turn.

Our do-it-yourself experiment-and-education formula isn't adapted in whole cloth to institutions and agencies, of course, but they can learn a lot from it, especially about communication with land-users. Let me sum up the reasons why it succeeded.

First, we appealed to the human love of excitement, discovery and drama, and made the informal research program seem like high adventure. Farmers and ranchers were thrilled to take part in what had always been a "spectator sport" played by professionals only. The project wiped out the barrier between land-users and the professionals who helped with it.

Second, we communicated with land-users — in speeches, newspaper and magazine articles, radio and TV programs, handouts, and by word of mouth personally — in direct, simple language, instead of the language of the graduate school.

There's a great temptation for professionals to express themselves in elaborate academic phraseology to impress their peers and the public. College students learn this as freshmen, by imitating their instructors. By the time they've escaped from graduate school, they're so used to it that they don't know they're doing it. How much easier it is to string together a train of well-worn professional clichés than to develop a fresh, graphic style of expression!

This, however, is *not* the way to win friends and influence intelligent laymen. A scientific truth is no less valid or respectable for being expressed in simple honest, earthy language that will inspire the public to put it to use.

Third, instead of expounding abstract ideas, we expressed those ideas in terms of experience, showing how they worked out in real life. As cooperators tried out new ideas and found them successful, we reported their stories in such a way that readers found it easy to identify with them and accept those ideas.

Fourth, instead of trying to make ourselves important to our cooperators, we made them important to each other and to us:

"Let us know how this new idea in stand establishment works, so we can tell the rest of the boys."

"You want to know how all-season pastures pan out? Go talk to Ted Johnson—he's had one five years."

Most people's lives seem drab and inconsequential to them. If you can give them a sense of self-consequence and significance, they'll climb on almost any bandwagon. One old hardshell proudly told us that he'd had 178 visitors to his grass-planting that summer. It was the high spot of his life.

A Forest Service grazing supervisor I knew in Colorado stood ace-high with ranchers.

"Barry," I asked him, "how did you get all these rugged individualists eating out of your hand this way?"

He laughed. "When I want 'em to do something," he said, "I make 'em think *they* thought it up!"

We didn't do that, exactly. But we did supplement the accumulated findings of formal research with a do-it-yourself program in which land-users themselves pushed back the frontiers of knowledge and experience with our help and the help of the generous-spirited professionals who worked with us. How they loved it!

Last and most important of all, we applied the principle of imaginative thinking—inventing new ideas and discovering new relationships by putting old ideas together in new ways—to everything we did, everything we wrote, everything we said, to knit all parts of the program together and give it meaning and impact. We got land-users to respond with their hearts as well as their minds, by appealing to their appreciation of beauty, their sense of personal and historical significance, their instinct for "one-ness" with the land, their sense of humor, personal pride, self-respect, desire for success and financial security, and love of excitement and drama. Thus we inspired them to *act*.

Five Poisonous Range Weeds—When and Why They Are Dangerous

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Highlight

Three larkspurs, halogeton, and western falsehellebore were examined for seasonal variation of their contained poisons. With the exception of low larkspur, greatest concentrations of the poisons were found in the leaves. Alkaloid concentration in tall larkspurs decreased with plant maturity. Cattle losses may be reduced if tall larkspurs are avoided during early vegetative growth. The alkaloid content of tall larkspurs was increased by treatment with 2,4,5-T and silvex. Only 2,4,5-T increased alkaloid content of western falsehellebore.

Poisonous plants have always constituted an indigenous component of the flora of the Western range. Halogeton *(Halogeton glomeratus* (M. Bieb.) C. A. Mey.) is the only one of our most troublesome poisonous weeds which has been introduced.

The native larkspurs *(Delphinium* spp.), western falsehellebore *(Veratrum californicum* Durand), and halogeton have become management problems by (1) introducing domestic animals where these weeds are prevalent; and (2) range misuse, particularly overgrazing, which permits weeds to increase in density and invade new areas at the expense of desirable vegetation.

Apart from recognizing these species in the field, few understand the complex physiological characteristics peculiar to each, such as the poison or poisons it contains; why only certain classes of livestock are poisoned; the distribution of the poison within the plant; how the poison content varies during the plant's life cycle, and the effect of climate and herbicides on the concentration of the poison.

Information on the characteristics and properties of plant poisons has been reported by Dye (1956), Williams (1960), Cook and Stoddart (1953), and Morton et al. (1959), on halogeton; Beath (1919, 1925), and Williams and Cronin (1963), on larkspurs; and Keeler and Binns (1964), on falsehellebore. Our continuing research was conducted with five poisonous species common in the Intermountain West: duncecap larkspur, *(Delphinium occidentale* S. Wats.; tall larkspur, *D. barbeyi* (Huth) Huth; low larkspur, *D. nelsonii* Greene; halogeton, *Halogeton glomeratus* (M. Bieb.) C. A. Mey.; and western falsehellebore *Veratrum californicum* Durand. With the exception of duncecap larkspur, the common names used are those approved by the Terminology Committee of the Weed Society of America (Darrow et al., 1962). Duncecap larkspur is designated as the common name for *Delphinium occidentale* in Standardized Plant Names (Kelsey and Dayton, 1942). Unfortunately, duncecap larkspur is usually called tall larkspur in the West and is therefore frequently confused with *Delphinium barbeyi.*

Materials and Methods

Plants were collected by locations, as follows: low larkspur, duncecap larkspur, and western falsehellebore, Wasatch Mountains east of Logan, Utah; tall larkspur, Wasatch Plateau east of Manti, Utah; halogeton, west of Snowville, Utah. Plants were sampled weekly in the field from soon after emergence until termination of their active growth. Plants were divided into leaf, stem, flower, and leaf-seed-sepal fractions, according to species and season. When possible, the same species was sampled at different elevations on the same date. The individual plant parts were dried for 24 hr at 60 C, ground to a 40-mesh powder, and stored in air-tight polyethylene containers.

Larkspurs and falsehellebore were analyzed for total alkaloids as previously described for tall larkspur (Williams and Cronin, 1963). Soluble and total oxalates in halogeton were determined by the method of Dye (1956). The above plants have, for a number of seasons, been analyzed for changes in the concentration of their contained poison following applications of experimental herbicides. Samples were taken 1, 2, and 3 weeks after treatment, and processed and analyzed as described.

Results and Discussion

Tall and Duncecap Larkspur.—More cattle are killed in the West by tall larkspurs than any other poisonous weed. Authenticated cattle losses attributed to tall larkspur on one grazing allotment in Utah have ranged from 2 to 12% during the last 10 years.

Plants begin growth in late spring as soon as snow has melted. As many as 20 to 30 shoots may arise from a single crown. In the vegetative stage, tall larkspurs resemble the poisonous monkshood, *Aconitum columbianum* Nutt. Tall larkspurs, however, have hollow stems and prefer well-drained soils, while monkshood has a solid, pithy stem and occurs on moist sites. Flowers of the two genera are easily distinguished because the calyx on monkshood lacks the spur characteristic of larkspurs.

Tall larkspurs produce flowers from July to September. The flowering plants average 3 to 4 ft in height but may reach 6 ft or more. Tall larkspurs grow at an elevation of 6,000 to 11,000 ft,

Table 1. Percent total alkaloids in plant tissue of duncecap larkspur, western falsehellebore, and low larkspur, 1965.

Date of Collection	Duncecap larkspur 7000 ft Apex	Leaves	Stems	Duncecap larkspur 8000 ft Apex	Leaves	Stems	Western falsehellebore 6000 ft Leaves	Stems	Western falsehellebore 8000 ft Leaves	Stems	Low larkspur 8000 ft Leaves	Stems	Flowers
May 28	—	—	—	—	—	—	0.3	0.5	—	—	—	—	—
June 3	—	—	—	—	—	—	0.3	0.2	—	—	—	—	—
June 10	4.1	3.7	2.6	—	—	—	0.2	0.2	—	—	—	—	—
June 17	2.5	2.4	1.5	—	—	—	0.2	0.1	—	—	—	—	—
June 23	3.0	2.3	1.1	5.4	3.5	3.5	0.2	0.2	0.4	0.4	0.2	0.1	—
June 29	2.6	2.1	1.0	4.6	4.5	3.4	0.2	0.2	0.5	0.3	0.2	0.2	—
July 8	3.3	2.1	0.7	3.1	2.7	1.5	0.2	0.2	0.2	0.2	0.2	0.4	0.5
July 15	3.3	1.8	0.6	3.3	3.2	1.1	0.3	0.3	0.2	0.2	0.3	0.3	0.6
July 21	2.8	1.6	0.7	3.5	2.8	1.1	0.2	0.1	0.2	0.2	0.2	0.2	0.4
July 28	2.3	1.3	0.8	3.3	2.2	1.1	0.2	0.2	0.2	0.2	—	0.3**	—
August 5	2.0	0.9	0.8	2.6	1.6	1.1	0.3	0.2	0.3	0.2	—	0.2**	—
August 12	2.1	1.2	0.6	2.0	1.6	0.6	0.2	0.1	0.2	0.1	—	0.2**	—
August 19	0.9	0.6	0.4	2.3	1.4	0.5	0.2	0.2	0.3	0.2	—	—	—
August 26	0.8	0.6	0.4	2.3	1.2	0.7	0.2*	0.2*	0.2	0.1	—	—	—
September 2	0.8	0.6	0.3	2.8	1.0	0.5	—	—	0.2*	0.2*	—	—	—
September 9	0.6	0.5	0.3	1.9	0.8	0.7	—	—	—	—	—	—	—
September 20	—	—	—	1.0*	0.3*	0.4*	—	—	—	—	—	—	—

* Plants dead
** Whole plant samples only

either on open meadows or interspersed among aspen and fir. Tall larkspur may be distinguished from duncecap larkspur by the tawny pubsecence of its inflorescence and by its tendency to produce bi-colored (light blue and dark blue) petals. Tall larkspur occurs in Arizona, New Mexico, Colorado, and Southern Wyoming and Utah (south of Provo). Duncecap larkspur grows generally north of tall larkspur in Northern Utah, Idaho, Nevada, Northern Wyoming, Montana, Oregon, and Washington.

The toxic substances in larkspurs are alkaloids. These compounds are complex organic molecules which contain, in addition to carbon, hydrogen and oxygen, a small amount of nitrogen. Alkaloids are widely distributed throughout the plant kingdom. Many that occur in small amounts in food are harmless but other alkaloids, such as morphine, atropine, and strychnine, are highly poisonous, though all three have great medicinal value under controlled use. Familiar examples of alkaloids are caffeine in coffee and nicotine in tobacco.

Tall larkspurs are most poisonous during early growth, especially during the first few weeks following emergence (Table 1). Alkaloid content decreases rapidly until flowering, during which alkaloid levels drop more slowly. After the plants have reached full flower, alkaloids rapidly decline. At 7,000 ft elevation, the apex consisted of leaves June 10 to July 1; buds July 1 to 15; flowers July 15 to 30; and seed pods and seeds thereafter. Equivalent growth stages in plants collected at 8,000 ft occurred 2 to 3 weeks later.

The majority of the alkaloids are found in the green leaf. Young leaves, particularly the apical bud, are rich in alkaloids. Stems are high in alkaloids only when very young and succulent; and as they become more woody, the concentration of the poison drops very rapidly. Before the bud stage of development, the dry weight of the plant is about evenly distributed between the leaves and stems. After flowering the older leaves begin to die, thereby reducing the percent dry weight of the leaves in a whole plant sample.

In years when cattle losses from tall larkspurs are unusually heavy, ranchers frequently assume that the plants are more toxic than usual. This assumption is true if losses occur following a winter of above normal snowfall or if the spring is unusually cold. The toxicity of larkspur is dependent upon two conditions: date of emergence, largely determined by winter snowfall, and temperature following emergence. Toxicity corresponds very closely to stage of growth. The later the start of growth, the more toxic plants will be at any particular date during the growing season. Cold weather following emergence can further retard development.

Duncecap larkspur (Table 1) was collected at 7,000 and 8,000 ft elevations. Plants at 7,000 ft were 18 to 20 inches high before snow had melted at 8,000 ft. Consequently, the stage of development of plants at 8,000 ft was 3 weeks behind those at the lower elevation. Until late in the season, higher elevation plants contained a larger concentration of alkaloids than lower ones at each date of collection. Duncecap larkspur, collected on September 9, 1965, at a site above 8,000 ft, from which snow did not melt until August, contained 1.3% and 0.7% alkaloids in the leaves and stems, respectively. These plants were flowering, and at a stage of growth comparable to larkspur on July 28 on the 7,000 ft site. The similarity in alkaloid content is striking and emphasizes the close correlation between stage of growth and toxicity in tall larkspurs.

Because of above normal snowfall, tall larkspur at Manti did not emerge on many sites until August. The alkaloid content of both leaves and stems was much higher than at comparable dates in 1963, when the growing season began earlier (Table 2).

We have no information regarding larkspur toxicity as influenced by moist or dry growing-seasons. One would suspect that alkaloid metabolism in deep-rooted perennial tall larkspurs would seldom be affected by moisture limitations at higher elevations. Abnormally heavy cattle losses during a season when tall larkspur begins early growth cannot be traced to excessive toxicity in the plants; rather, conditions favoring increased consumption of the plants must be responsible—poor range condition, lack of forage, or releasing hungry animals onto land heavily infested with larkspur.

Table 2. Seasonal distribution of alkaloids (percent) in tall larkspur.

Date of collection*	1965 Lvs.	1965 Stems	1963 Lvs.	1963 Stems
July 10	—	—	2.8	2.8
July 18	—	—	2.5	1.4
July 23	3.4	2.1	1.9	0.9
July 30	2.8	1.6	1.8	0.5
Aug. 4	2.8	1.3	1.7	0.4
Aug. 11	1.9	1.4	1.2	0.4
Aug. 17	1.5	0.7	1.1	0.3
Aug. 27	1.3	0.4	1.0	0.2
Sept. 3	1.9	0.8	0.5	0.2
Sept. 7	0.9	0.7	0.4	0.1

* Dates are for 1965. Dates for 1963 were either the same or varied by only 1 or 2 days.

Most losses from tall larkspurs occur within 2 weeks after cattle reach infested areas. Plants usually have not reached full-bloom and are therefore highly poisonous. Few losses occur after the full-bloom stage of growth is over. Alkaloid level in duncecap larkspur at 7,000 ft declined to less than half by full-flower in mid-July. By September the plants were, at most, only about one-seventh as toxic as on June 10. Since stems account for an increasing percentage of the dry weight later in the season, the actual toxicity was undoubtedly much less.

Tall larkspurs are not unpalatable to cattle, and releasing a hungry herd onto an infested area merely invites disaster.

Low larkspur.—Low larkspur is widely distributed from South Dakota westward to Colorado, Wyoming, Utah, and Idaho, where it thrives on foothills, plains, and open mountain meadows. The plants emerge in early spring after snow melt, flower in June and July, then dry up and disappear. Each plant consists of one or two stems, two to six leaves, and, when in full flower, it reaches a height of 1 to 2 ft.

Low larkspur alkaloid levels do not vary greatly during its short growing season except that they tend to be higher during flowering. The small leaves dry rapidly after flowering; therefore, only whole plant samples were collected late in the season (Table 1). The alkaloid content is only 10 to 20% of that found in the tall larkspurs; therefore, cattle losses tend to be less severe. At the site where these collections were made, the plants had largely matured and disappeared before cattle were released on the area.

Alkaloid concentration does not, alone, determine larkspur toxicity. Each species contains several alkaloids, some of which are more toxic than others; therefore, the toxicity of individual species will depend upon type and concentration of alkaloid. The same alkaloid may occur in several species of larkspur; others are unique only to one species. Beath (1925) extracted crude alkaloids from five species of larkspur, including those discussed here, and evaluated their relative toxicity via intravenous injections in rabbits. Alkaloids from low larkspur were most toxic, while alkaloids from tall larkspur were only slightly less poisonous. Alkaloids from tall and low larkspurs were three and four times more poisonous, respectively, than alkaloids from duncecap larkspur. The alkaloids of duncecap larkspur were the least poisonous of the five species examined. On the range, however, duncecap larkspur is actually more poisonous than low larkspur, since it contains up to 10 times more alkaloids per gram of plant tissue. Tall larkspur not only contains the more poisonous types of alkaloids, but produces them in concentrations equal to any other tall larkspur. The heavy cattle losses caused by this species are, therefore, not suprising. Clawson (1933) reported that the lethal dose of young tall larkspur may be as low as 0.7% of an animal's weight, or roughly 3.5 lb for a 500-lb animal.

A few seconds of additional grazing on any larkspur species may mean the difference between mild symptoms and fatal poisoning. It should not, for practical purposes, be inferred that alkaloid toxicity varies to the extent that various species can be categorized as "more toxic" or "less toxic". All species are dangerous. But cattle losses recorded over the years suggest that tall larkspur must rank first as a killer in the Rocky Mountain region.

Western Falsehellebore.—Western falsehellebore is a tall,

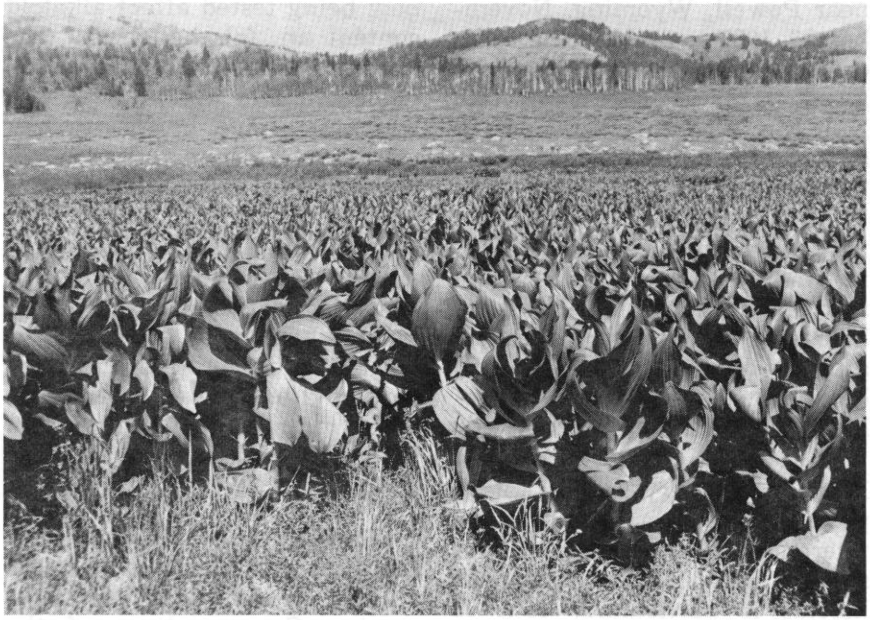

FIG. 1. Western falsehellebore infestation on a mountain meadow, Cache National Forest, Idaho.

robust member of the lily family which grows above 5,500 ft elevation. In flower the plant stands 6 to 8 ft tall. Individual leaves measure up to 9 x 12 inches. Plants emerge as soon as snow melts, flower in July and August, and set seed in September. Seed production is erratic, however, and in some years plants may dry up and become dormant while in full flower. Plants rooted in moist seeps become dormant as rapidly as those on dry sites. In 1964, seed production was abundant. In 1965, few flowers and no seed were produced on the same area even though moisture and growing conditions were more favorable than during the preceeding year.

Several alkaloids are found in western falsehellebore (Keeler and Binns, 1964). One or more of these acts as a teratogenic agent which causes severe malformations in lambs if the ewe eats the plant during the very early stages of gestation (Binns et al., 1963). This problem has been particularly severe in Idaho where ewes are bred on the range for early lamb production. Both larkspurs and falsehellebore contain monobasic and steroidal-type alkaloids, but are not known to contain the same specific alkaloids. Falsehellebore is seldom grazed by cattle; therefore losses are almost entirely confined to sheep.

Alkaloid content in falsehellebore is highest when plants emerge. The level drops quickly to about 0.2% of the dry weight of the plant. The alkaloid concentration varies slightly above or below this figure throughout the season until the plant dies. The stems contain slightly less alkaloid. Flowers have little or no alkaloid content.

The altitude difference in Table 1 represents 2,000 ft. Late emerging plants were higher in alkaloids than older plants at lower elevations only for a period of 2 weeks. After July 8, no significant differences in alkaloid levels were apparent.

The data indicates that falsehellebore is capable of producing its toxic effects with almost uniform intensity throughout the growing season. Dead but undecomposed leaves are frequently as high in alkaloids as the green leaf.

Halogeton. — Halogeton is an annual of the goosefoot family which, since its introduction 30 years ago, has invaded 12 million acres of Western rangeland. The plant contains unusually heavy concentrations of soluble oxalates which are bound primarily as sodium salts. Oxalates are readily absorbed into the circulatory system of the affected animal. There the two sodium ions are replaced by one calcium withdrawn from the serum calcium. Excessive depression of the serum calcium level is inevitably fatal. Calcium oxalates are then precipitated primarily in the liver and kidneys where they interfere with normal function of these organs.

Soluble oxalates are highest in the leaves and lowest in stems of halogeton (Table 3). Seed contains about 2% soluble oxalates (Williams, 1960). Though halogeton produces primarily soluble oxalates, some insoluble oxalates, primarily salts of calcium, are present. Insoluble oxalates are not absorbed; therefore they are nontoxic. Soluble oxalates predominate in the leaves while insoluble oxalates occur in higher concentrations in the stems.

The oxalate content of the halogeton leaf tends to be relatively high during midsummer, then peak in September (Williams, 1960). The data in Table 3,

Table 3. Seasonal distribution of soluble and insoluble oxalates (percent) in stem and leaf-seed-sepal fractions of halogeton.

Date of collection	Lf.-seed-sepal Sol.	Lf.-seed-sepal Insol.	Stems Sol.	Stems Insol.
June 24	25.0	3.2	3.4	7.6
July 9	24.3	4.5	2.9	6.0
July 22	22.6	4.9	4.1	6.1
Aug. 6	22.3	5.3	2.3	2.6
Aug. 19	22.9	1.7	3.8	4.5
Sept. 3	19.1	5.4	1.1	3.7
Sept. 17	16.4	3.5	1.6	5.5
Oct. 1	16.3	3.4	1.6	4.2
Oct. 15	24.5	3.9	4.0	3.9
Oct. 28	24.4	9.0	2.1	4.8
Nov. 12	25.5	3.1	1.9	2.6
Nov. 23	19.1	3.0	1.9	3.6

however, represent a leaf-seed-sepal fraction, so that the lower oxalate content noted from September to early October represents inclusion of flowers, seeds, and sepals — all of which are lower in oxalates and thereby dilute the overall oxalate concentration. By mid-October seeds began to disperse, samples contained a greater percentage of leaves, and oxalate percentage responded upward accordingly. When only pure leaf samples are collected, one may expect soluble oxalate content to exceed 30% from late August or early September to frost and later, depending upon climatic conditions. A leaf sample collected near Cisco, Utah, in November contained 38.25% soluble oxalates, the highest concentration that we have found.

The toxicity of the dead plants during the winter is largely dependent upon weather. Windstorms, hail, and heavy rain will remove leaves from standing plants, reducing oxalate content. Rain will leach some soluble oxalates from the leaves. A record November rainfall occurred throughout Northern Utah from November 12 through November 25, 1965. The leaching effect of this precipitation may be noted in the markedly decreased soluble oxalate content in leaves collected on November 23 (Table 3). If fall and winter precipitation is light, the leaf-seed-sepal fraction may contain more than 30% soluble oxalates as late as mid-February (Dye, 1956). Since dead halogeton remains almost as poisonous as the living plant, it should be avoided at all times.

Halogeton is confined largely to desert valleys; therefore, oxalate concentration is not affected by changes in elevation. Oxalates occur in such copious quantities that geographical distribution, as it now exists, would not cause notable, or significant, differences in the oxalate levels of halogeton. Halogeton collected near Powell, Wyoming, November 26, 1965, contained the same concentration of soluble oxalates found in plants from Snowville, Utah. In Wyoming Bohmont et al. (1955) found that oxalate content in halogeton ranged from 14 to 21%; this is no different from whole plant analyses made in Utah, Nevada, and Idaho. The fact that sheep are rarely lost to halogeton in Wyoming must be attributed to good management, better range condition, and perhaps lower halogeton densities.

Type of Livestock Poisoned.— For almost every kind of plant poison there is a difference in tolerance with each class of livestock. Tolerance of cattle for alkaloids is particularly low. A dose of larkspur fatal for cattle, based on body weight, may or may not even produce symptoms in sheep. The reasons for these differences are not known. Apparently the microflora of the sheep's digestive system are more efficient in breaking down or detoxifying alkaloids. Cattle escape halogeton and falsehellebore poisoning largely because they avoid these species. The few authenticated examples of halogeton poisoning in cattle were reported from an area where this weed constituted virtually the only available herbage.

Herbicides. — Two herbicides, 2,4,5-trichlorophenoxyacetic acid (2,4,5-T) and 2-(2,4,5-trichlorophenoxy) propionic acid (silvex), increased alkaloid content in tall larkspur (Williams and Cronin, 1963) and duncecap larkspur. In some years application of these herbicides has doubled the alkaloid content of the leaves and stems for 2 or 3 weeks after treatment. Among the many experimental herbicides evaluated for control of western falsehellebore, only 2,4,5-T increases alkaloid content. Fortunately, the low effectiveness of this herbicide precludes its use in controlling this species.

None of the five best herbicides now being tested affect alkaloid content in falsehellebore. The concentrations of oxalates in halogeton and alkaloids in low larkspur have been neither raised nor lowered by any herbicides thus far evaluated, including 2,4,5-T and silvex. Because the tall larkspurs may be more toxic following applications of phenoxy herbicides, particularly silvex and 2,4,5-T, post-treatment grazing should be restricted 2 to 3 weeks after treatment and until the plants begin to dry and lose their palatability.

Summary

Distribution and seasonal changes of toxic compounds were studied in five poisonous range species. Concentrations of the poisons declined with maturity in two tall larkspurs; remained relatively unchanged in western falsehellebore and halogeton; and peaked at flowering in low larkspur. With the exception of low larkspur, the majority of the toxic principle was always found in the leaves.

The toxicity of tall and duncecap larkspur was closely determined by stage of maturity. These species tend to be more poisonous later in the season if their emergence is delayed by late snow melt, or if subsequent growth is retarded by cold weather. As elevation increased, duncecap larkspur contained a greater concentration of alkaloids at any given date.

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Emergence and Survival of Intermediate Wheatgrass and Smooth Brome Seeded on A Mountain Range[1]

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Highlight

Intermediate wheatgrass and smooth brome were seeded at 2 depths and 3 seasons for 3 years to determine the best season and depth for seeding mountain ranges. Emergence was best from seeding in September, October, and June, in that order. Seeding at the 0.5- and 1-inch depths gave similar results. Low emergence and high mortality of all treatments indicate the need for additional information on seeding harsh sites on mountain ranges.

Season and depth of seeding grasses on mountain rangelands may influence their emergence, survival, and productivity. On Western mountain rangelands Hull et al. (1962) found low emergence and low survival of seeded grasses. They indicated that further information is needed for successful seeding of these lands.

Plummer and Fenley (1950) seeded six grasses in the subalpine zone in central Utah. Percent seedling survival of the three best species planted at six seeding seasons over a 5-year period was: Late spring, 26; early summer, 24; early spring, 20; late fall, 14; late summer, 12; and early fall, 10. Frost heaving was the major cause of seedling death. Also in central Utah, Frischknecht (1951) seeded 16 species on a sagebrush and on a mountain brush site. Emergence was best from seeding in the early fall, early spring and late fall in that order. Season of seeding made little difference in survival. Sixteen to 22% of the seeds produced established plants on the mountain brush site and 5 to 7% on the sagebrush site. Fall-seeded plants died mainly from frost damage. Spring-seeded plants died mainly from drought. In the mountain brush type in southern Idaho, Hull (1948) found 5 to 22% survival of 4 grasses seeded at 2 depths and 16 seeding dates per year over a 3-year period.

Bleak (1959) in central Utah reported that seeds of smooth brome (*Bromus inermis* Leyss.), tall oatgrass (*Arrhenatherum elatius* (L.) Presl), and intermediate wheatgrass (*Agropyron intermedium* (Host) Beauv.), seeded in late fall or early winter, germinated and produced roots and shoots under a deep snow cover. Hull (1960) also determined this for intermediate wheatgrass at a high elevation in southeastern Idaho.

Laude (1956) subjected six grasses in different stages of preemergence to controlled freezing. Emergence decreased as the preemergence period lengthened. The decreased emergence was attributed to injury by low temperatures and soil pathogens.

Holmgren and Basile (1959) found that germination of bitterbrush (*Purshia tridentata* (Pursh) DC.) seeds planted 0.5 inch or more deep was delayed so that plants avoided the high frost heaving loss which accompanied early spring emergence from shallow seedings.

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[1] *Cooperative research between Crops Research Division, Agricultural Research Service, U. S. Department of Agriculture, and Utah Agr. Exp. Station, Logan, Utah. I thank Glenn Carnahan and Wesley Bitters, former students who assisted with field phases of the study, and E. James Koch, Biometrical Services, Agricultural Research Service, Beltsville, Maryland, who made the statistical analysis. Utah Agricultural Experiment Station Journal Paper 457.*

The present study was conducted to determine the best time and depth of planting intermediate wheatgrass and smooth brome on mountain rangelands.

Procedures

The experimental area is a harsh site in a depleted weedy opening in the spruce-fir type in Franklin Basin in southeastern Idaho. Vegetation is mainly tarweed *(Madia glomerata* Hook.) and other small annuals and many fleshy-rooted, spring-growing ephemerals. The seeded area is 8,400 ft elevation and slopes 3% west. The top 12 inches of soil is a clay loam with 47% moisture at saturation, 28 at ⅓ atmosphere and 11 at 15 atmospheres. During the 3 years of the study, permanent snow came on November 2, November 22, and October 27. Snow melted June 5, May 24, and May 20. Rainfall from June 1 to September 30 averages 6.7 inches. The annual precipitation is 46.1 inches. Precipitation during the 3-year study was near normal, except that the first fall was dry with only 0.6 inch of precipitation from August 24 until permanent snow on November 2.

Summer, that is, June through August, air temperatures during the years of the study reached daily maximums of from 65 to 87 F. Minimum summer temperatures during the 3 years were 18, 26, and 28 F. respectively. Temperatures during September and October sometimes dropped to zero. Soil temperatures at the 0.75-inch depth often reached 120 F. during the summer.

Intermediate wheatgrass and smooth brome, known from previous trials to be well adapted in this area, were seeded 0.5 and 1 inch deep in early fall, late fall, and early spring from 1958 to 1961. Early fall seedings were made September 10, 8, and 14 for the 3 years. Late fall seedings were made October 25, 31, and 30; and spring seedings were made June 11, 3, and 1. Additional seedings were made at each date and depth, so that plants could be dug to determine root depths.

Furrows were made by hand and soil covering the seed was compacted with a board to simulate packing with press wheels on a small drill. Fifty seeds with 94% viability were spaced 1 inch apart in each furrow. The furrows were spaced 1 ft apart.

Table 1. Time and percent emergence and survival of intermediate wheatgrass seeded at 2 depths at each of 3 seasons for 3 years.

Year seeded	Time of Emergence[a]	Early fall 0.5	Early fall 1	Late fall 0.5	Late fall 1	Spring 0.5	Spring 1
First year							
1958-59	June 1959	10.3	12.0	15.5	15.0	1.7	2.2
	July 1959	.2	.7	0	1.0	4.3	4.3
	Sept. 1959	0	.3	0	0	0	0
Total emergence		10.5	13.0	15.5	16.0	6.0	6.5
Survival		2.2	3.3	2.8	5.7	.7	.5
Second year							
1959-60	Oct. 1959	12.3	6.3	—	—	—	—
	Nov. 1959	6.0	4.0	0	.5	—	—
	May 1960	7.5	7.8	15.2	8.5	—	—
	June 1960	2.5	2.2	5.3	3.0	10.5	9.0
	Aug. 1960	0	.2	0	0	.2	.5
	Sept. 1960	.5	0	0	0	1.8	1.0
Total emergence		28.8	20.5	20.5	12.0	12.5	10.5
Survival		0	1.0	.5	.2	0	.3
Third year							
1960-61	Oct. 1960	12.0	16.5	—	—	—	—
	May 1961	5.7	1.5	1.5	2.3	—	—
	June 1961	7.8	6.0	8.0	4.5	5.5	2.0
	July 1961	1.0	1.7	1.0	.5	.3	.2
Total emergence		26.5	25.7	10.5	7.3	5.8	2.2
Survival		1.0	.5	1.2	0	.8	1.0
All years							
Average emergence		21.8	19.7	15.5	11.8	8.1	6.4
Average survival		1.1	1.6	1.5	2.0	.5	.6

[a] Months in which there was no emergence are omitted from the table.

Table 2. Time and percent emergence and survival of smooth brome seeded at 2 depths at each of 3 seasons for 3 years.

Year seeded	Time of Emergence[a]	Early fall 0.5	Early fall 1	Late fall 0.5	Late fall 1	Spring 0.5	Spring 1
First year							
1958-59	June 1959	2.0	2.5	1.1	1.2	1.0	.7
	July 1959	0	0	.2	.3	.5	.5
Total emergence		2.0	2.5	1.2	1.5	1.5	1.2
Survival		.5	.5	.5	.5	0	0
Second year							
1959-60	Oct. 1959	2.0	1.2	—	—	—	—
	Nov. 1959	2.5	.3	0	0	—	—
	May 1960	2.0	1.5	1.0	.3	—	—
	June 1960	.5	.2	5.0	2.7	5.7	2.5
	Sept. 1960	0	.3	.5	—	.8	.5
Total emergence		7.0	3.5	6.5	3.0	6.5	3.0
Survival		0	0	1.0	.7	.7	0
Third year							
1960-61	Oct. 1960	2.2	9.0	—	—	—	—
	May 1961	.5	.5	.3	.2	—	—
	June 1961	1.5	2.0	.2	.8	1.0	.5
	July 1961	.3	.2	0	0	.5	0
Total emergence		4.5	11.7	.5	1.0	1.5	.5
Survival		.8	1.5	0	0	0	0
All years							
Average emergence		4.5	5.9	2.7	1.8	3.2	1.6
Average survival		.4	.7	.5	.4	.2	0

[a] Months in which there was no emergence are omitted from the table.

The study was set up as a randomized block with 8 replicate blocks for each year.

Seedling emergence and death were marked with colored wire stakes each week during the snow-free season for 4 years following seeding (Tables 1 and 2). Significance of results at the 5% level was determined by Duncan's (1955) multiple range test. Many interactions were significant. Where interactions help explain results, they are discussed with the treatments.

Results and Discussion

For the entire study, average seedling emergence for intermediate wheatgrass was 13.9 plants per 100 seeds of which 1.2 plants survived (Table 3). Smooth brome emergence was 3.3 plants per 100 seeds with 0.4 plants surviving. Based on the plants which emerged, this was a 91% death loss for intermediate wheatgrass and 88% for smooth brome. Planting at 1 seed per inch results in 5.9 lb/acre for intermediate wheatgrass and 3.8 lb for smooth brome. Final survival was 1 plant per 7 ft^2 for intermediate wheatgrass and 1 plant per 21 ft for smooth brome; certainly not a good stand of either species.

Depth of seeding—There was no significant difference in emergence or survival from the two seeding depths for either species. Because of non-significance, both depths are combined in Table 3. The interactions of depth with season and with species were not significant. In the depth x year x species interactions, emergence of intermediate wheatgrass and smooth brome was significantly better from the 0.5-inch depth than from the 1-inch depth during the second year. Other depth interactions were not significant.

Season of seeding—Seedling emergence from early fall seeding of intermediate wheatgrass was significantly better than from late fall seeding, which in turn was significantly better than spring seeding (Table 3). Emergence of smooth brome was significantly better from early fall seeding than from seeding in late fall or spring. These last two were similar in emergence. In survival there was no significant difference between the two fall seedings of either species, but both fall seedings were significantly better than spring seeding.

September seedings emerged mainly in fall, winter, and early spring, with some emergence delayed until summer and in 2 years until early fall, (Tables 1 and 2). In the fall of 1958, the soil was dry until permanent snow on November 2. We observed, however, that ger-

FIG. 1. Seedling loss is severe when freezing and thawing occur during spring snow melt. Top—Snow melting on June 4, 1959, at Franklin Basin. Center—Frost crystals near edge of melting snow raise seedlings of intermediate wheatgrass out of the ground. Bottom—Dead grass seedlings on the soil surface after frost crystals melt.

Table 3. Percent emergence and survival of intermediate wheatgrass and smooth brome when seeded at 3 seasons during each of 3 years.

	Emergence			*Survival*		
	Intermediate wheatgrass	Smooth brome	Ave.	Intermediate wheatgrass	Smooth brome	Ave.
Seasons						
Early fall	20.8[a]*	5.2[c]	13.0[a]	1.4[a]	.6[b]	1.0[a]
Late fall	13.7[b]	2.2[d]	8.0[b]	1.7[a]	.4[b]	1.0[a]
Spring	7.3[c]	2.4[d]	4.8[c]	.5[b]	.1[c]	.3[b]
Years						
1958-59	11.3[b]	1.6[d]	6.5[b]	2.5[a]	.3[c]	1.4[a]
1959-60	17.5[a]	4.9[c]	11.2[a]	.3[c]	.4[c]	.4[b]
1960-61	13.0[b]	3.3[cd]	8.1[ab]	.7[b]	.4[c]	.5[b]
Average	13.9	3.3	8.6	1.2	.4	.8

* For emergence or survival, any two means followed by the same letter are not significantly different at the 5-percent level.

Table 4. Average death loss (percent) of intermediate wheatgrass and smooth brome seeded at 3 seasons in each of 3 years.

Season of seeding	Period and amount of death loss: 1st fall & spr	1st sum*	2nd-4th fall & spr	Sur.
Early fall	57	23	11	9
Late fall	24	41	19	16
Spring	8	56	30	6
Average	30	40	20	10

* No summer death loss after the first summer.

FIG. 2. Freezing and thawing forces seedlings and older plants of intermediate wheatgrass out of the ground. Left—Seedlings which were forced out of the ground in early spring. Center—Two-year-old plants forced out of the ground during late fall. Right—A 4-year-old plant forced out of the ground in early spring.

mination and emergence of early and late fall seedings commenced in mid winter under the snow, but we did not count plants until after spring snow melt. Spring seedings usually emerged soon after planting and in the summer with some early fall emergence during 1960. All plants which emerged did so during the first growing season (Tables 1 and 2).

Plants seeded in September and October had similar root and shoot development during the first growing season, and plants from both fall seedings were superior to spring-seeded plants. For example, intermediate wheatgrass plants seeded in October of 1959 had tops which averaged 6.9 inches in height and roots 5.1 inches in length on August 21, 1960, as compared to 4.0 and 3.8 inches respectively for plants seeded in June 1960.

Years of seeding.—Emergence and survival varied with years (Table 3) and was influenced by precipitation, drought periods, temperature, and frost heaving. Relatively favorable precipitation and temperatures caused good emergence the second year. Spring and fall frost heaving, combined with low and ineffective precipitation during July, resulted in poor survival of emerged plants, especially in the second and third years.

Seedling establishment and death loss.—Seedling emergence was low and death loss was high for all treatments. The time and percent of death loss, based on emergence, was similar for both species, and they are averaged in Table 4. The average winter loss was 50% and the summer 40, leaving a 10% survival. The winter loss occurred during the fall and early spring when the soil was saturated and when there was freezing and thawing. (Fig. 1).

Drought or summer loss was confined to seedlings during their first summer. Frost injury during fall and spring was also most severe on newly germinated seedlings with only one or two spindly leaves. Plants with three or more wide leaves were seldom broken off. Most seedlings were broken off either at the bottom of the frozen soil layer or just above the seed. Some were forced out of the ground with seed and roots (Fig. 2).

Frost heaving continued to the fourth growing season when the study was terminated (Fig. 2). Older plants killed by frost were usually small, isolated, and poorly rooted. Plants with crowns at or below the soil level appeared better able to withstand drought and frost damage than plants with partially exposed crowns. Height of crown was not controlled by seeding depth in this study.

In some years, especially during the winter of 1960-61, many older plants perished which were not pushed out of the soil by frost heaving (Fig. 3). Evidence suggested that pathogens were a factor, but causal agents were not identified.

In an earlier study on the same site, intermediate wheatgrass was seeded 0.5-inch deep in 8 replications on June 12, 1958. Emergence was 22.2 seedlings per 100 seeds planted. Nine plants died during the first summer and 11 during freezing and thawing the first fall and the next spring. Plants continued to die each winter until at the end of 5 years there were 22 dead and 0.2 plants surviving per 100 seeds planted.

Two conditions were necessary for frost heaving: a wet soil, and freezing and thawing. These conditions were usually present following rains or temporary snow in late fall and during spring snow melt (Fig. 1). Only a few degrees below freezing resulted in seedling loss. Frost caused 24% loss of emerged seedlings during snow melt from May 31 to June 4, 1959. Minimum night temperatures during this period were 18, 22, 27, and 30 F.

The necessity of moisture for frost damage is typified by a fall seedling kill of 52% of emerged seedlings from seedings made Setpember 14, 1960. Seedlings commenced to emerge on October 1, and freezing occurred on October 4; but there was no frost heaving until after rain wet the soil on October 8. Seedling and plant loss occurred for 2 days until snow covered the ground on October 10. Minimum night temperatures were 24 and 30 F. Snow melted on October 17 and plant loss was again high to October 20 with night temperatures of 23, 30, 24, and 28 F. Temperatures were again low from October 24 until permanent snow on October 27, but there was little mortality as the soil had dried out between October 20 and 24.

This study shows the need of additional information on species, methods of planting, and especially on those factors that affect germination, emergence and survival on harsh sites on mountain ranges.

FIG. 3. A 4-year-old plant of intermediate wheatgrass which died in place during the winter of 1962-63.

Summary

Intermediate wheatgrass and smooth brome were seeded on mountain rangelands at 0.5- and 1-inch depths in early September, late October, and early June for 3 years. Intermediate wheatgrass averaged 13.9 plants emerged of which 1.2 survived per 100 seeds planted. Smooth brome emergence averaged 3.3% with 0.4 plants surviving.

Averaging both species, there was no significant difference between seeding 0.5 and 1 inch deep; emergence was best from seeding in September, October and June in that order; and fall seedings were similar in survival and both exceeded spring seeding.

The average late fall and early spring death loss from frost heaving was 50% and summer loss was 40%, leaving a 10% survival of the emerged plants. Frost heaving continued to the fourth growing season.

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Using Growing-Season Precipitation to Predict Crested Wheatgrass Yields

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Highlight

Forage available for use by livestock varies with the season in which ranges are used. Specific precipitation patterns accounted for 87% or more of the variation in forage yields of crested wheatgrass grazed at different seasons in the Front Range of Colorado. Rainfall in April determined forage yields of ranges grazed in the spring; May and July rainfall determined forage yields for fall-grazed ranges. Expected forage yields and stocking rates can therefore be predicted from precipitation measurements.

Frequently, one or two specific environmental factors exert major influence on plant growth. If these factors can be isolated from one another, reliably measured, and related to plant growth, then growth can be predicted simply by measuring the environmental factors. Throughout the western United States, studies have shown herbage production is often closely correlated with or largely controlled by precipitation.

In the desert Southwest, Nelson (1934) noted that height growth of black grama *(Bouteloua eriopoda* Torr.) was largely in response to current summer rainfall but more than one growing season with good rainfall was needed to improve vigor or alter the number and size of grass tufts. Lister and Schumacher (1937) found that density (basal area) and flowerstalk height of three important range grasses on the Santa Rita Experimental Range were significantly correlated with precipitation. They used a method based upon 15 months of precipitation to statistically predict changes in the above factors if more or less than the average moisture were received. They recognized too, that distribution of this moisture in different seasons resulted in one or the other of the species being favored.

For semiarid ranges in the Intermountain Region, several workers (Craddock and Forsling, 1938; Hutchings and Stewart, 1953; Blaisdell, 1958) obtained significant correlations between precipitation and herbage yields. Sneva and Hyder (1962) devised a method for estimating yields and stocking rates for these ranges based on adjustments from median yields and crop-year precipitation. They suggested the method should be useful for predicting median yields, both long-term and annual, on rangelands in much of the West. Their system, however, does not take into account yields at various periods within a growing season.

Springfield (1963), for seeded range in New Mexico, found that between 61 and 94% of the variation in forage yields of crested or desert wheatgrass *(Agropyron desertorum* (Fisch.) Schult.) was attributable to antecedent precipitation. Under a medium rate of grazing, a correlation coefficient of 0.97 was obtained between forage production and October-through-May precipitation. He pointed out, though, that to predict stocking rates for an upcoming season, a manager needs a basis for estimating yields before the end of May. Thus he suggested using a weaker relationship, between forage production and October-through-March precipitation. He cautioned that this estimate served only as a rough guide for developing management plans in advance of the grazing season and was subject to considerable error.

Current prediction methods are for an average or range in expected herbage for forage production for an entire growing season based upon either crop-year or antecedent precipitation. These predictions are usually adequate for estimating long-term stocking rates or benefits from a range improvement practice such as seeding, but they generally neglect "effective production"—herbage that is available for use at a particular time rather than at plant maturity or peak production. The present paper outlines a statistical approach that was found successful for estimating forage production and stocking rates on crested wheatgrass ranges grazed at different seasons in the Front Range of Colorado.

Study Area and Methods

Crested wheatgrass ranges in the current study were seeded in 1946 at the Manitou Experimental Forest, 28 miles northwest of Colorado Springs. The Forest is at an elevation of approximately 8,000 ft. Annual precipitation at the headquarters station averages 15.5 inches, with about 10.8 inches falling during the growing season from April through August. Soils of the study site are alluvial, and have been derived primarily from outwash material of Pikes Peak Granite. They generally have moderate amounts of organic matter, and are porous and well drained; they are classified as sandy loams.

Grazing Treatments.—From 1948 to 1956, the crested wheatgrass range was grazed lightly or not at all. In 1957, six pastures, each 3.3 acres, were fenced and grazed by yearling heifers at different seasons. Two areas were grazed in the spring from approximately April 25 to June 10, two in the fall from September 1

[1] *Forest Service, U. S. Department of Agriculture, with headquarters at Fort Collins in cooperation with Colorado State University.*

to about October 15, and two pastures were grazed both spring and fall each year. Animals were turned on the spring pastures when maximum leaf lengths of crested wheatgrass plants averaged approximately 3 inches.

To meet objectives of a more comprehensive study the pastures received heavy use. At all seasons the plants were grazed to a 1-inch stubble height, or approximately 80% use of the forage by weight. Production and utilization were estimated by the paired plot-difference method, with 12 plot pairs in each pasture. In years of high production, during the spring, plots were clipped and cages moved one to several times during the grazing period. In years of low production and in the fall, plots were harvested once immediately after grazing ended. Stocking rates for each seasonal treatment were computed in terms of yearling heifer-days of grazing per acre. Precipitation was measured at the headquarters weather station, approximately 0.5 mile from the pastures at a comparable elevation and exposure.

Analysis.—Previous work with several seeded species at Manitou, which involved analysis of various combinations of monthly precipitation, has shown that from 65 to 90% of the annual variation in forage yield results from fluctuations in April-through-August precipitation.[2] Because precipitation during each of the 5 months did not appear to contribute equally to forage yields, particularly when the ranges were grazed on a seasonal basis, "effective production" was analyzed for its dependence on monthly precipitation within the 5-month period. The analysis was made following the method described by Quenouille (1952). The premise of this approach is to select from a large number of independent variables only those which contribute significantly to the dependent variable through stepwise regression testing.[3]

[2] *Currie, Pat O. and Dwight R. Smith. Response of seeded ranges to different grazing intensities in the Ponderosa Pine Zone of Colorado. (In preparation for publication, Rocky Mountain Forest and Range Expt. Sta., U. S. Forest Serv., Fort Collins, Colo.).*

[3] *Computer programs for stepwise regression methods used are available at most statistical service libraries.*

Results and Discussion

Effective Forage Production in Relation to Precipitation.—Precipitation was quite variable during the 8-year study period. As shown in Table 1, April-through-August precipitation ranged from 6.36 to 16.25 inches, well above and below the study period mean of 10.45 inches. Wide extremes in individual months were also common. For example, April precipitation has averaged 1.65 inches over 28 years of weather records. In 1957, 2.80 inches were recorded during April, but in 1963 no measurable moisture was received.

Forage production from each of the seasonally grazed ranges showed comparable extremes. For those ranges grazed only in the spring, effective forage production ranged from 1,734 lb/acre in 1957 to essentially 0 in 1963 (Table 1). In comparison, when total precipitation for the 5-month growing season was only 7.83 inches in 1959, production was nearly 200 lb/acre more than in 1961 when growing season rainfall totaled 16.25 inches. Production in 1959 and 1961 on ranges that were grazed only in the fall showed just the opposite relationship, with a difference of 700 lb/acre more forage produced during the wetter year. Thus, effective forage production from ranges grazed at different seasons was controlled by the moisture received during specific months.

On ranges grazed only in spring, 88% of the variation in forage yield was accounted for by the amount of precipitation received in April (Table 2, Equation 1). In 6 of 8 years, plant growth to the 3-inch leaf length criteria used for stocking was not reached until after April 25, and occasionally it was early May before grazing began. Therefore, in a majority of years the first equation in Table 2 could be used to predict effective forage production without any adjustment in stocking date. In an occasional year when plant growth is sufficient for grazing before the end of April, stocking must be delayed a few days. This delay permits some additional plant growth, but provides the necessary data for predicting effective forage yields.

The equation for estimating production in the spring is not appropriate for determining the effective yields on ranges grazed both spring and fall. As shown by Equation 3a in Table 2, spring forage production during this split grazing season depended upon April and May precipita-

Table 1. Forage production from crested wheatgrass ranges at different seasons in relation to April-through-August precipitation, Manitou Experimental Forest.

Year	Precipitation in inches						Forage production in lb/acre			
	April	May	June	July	August	Total	Spring	Fall	Spring plus fall	
							only	only	Spring	Fall
	(x_1)	(x_2)	(x_3)	(x_4)	(x_5)		(y_s)	(y_f)	(y_s')	(y_f')
1957	2.80	3.63	1.10	6.20	1.89	15.62	1734	1894		
1958	1.59	3.75	0.57	1.99	2.28	10.18	1090	1362		
1959	1.50	1.43	1.44	1.22	2.24	7.83	1026	824	575	303
1960	0.72	1.96	0.60	2.69	0.72	6.69	708	926	654	302
1961	1.41	2.09	2.22	5.73	4.80	16.25	838	1525	822	914
1962	1.19	0.65	1.23	1.60	1.69	6.36	676	501	452	126
1963	0.00	0.23	2.37	1.81	8.79	13.20	0	741	0	896
1964	0.45	1.68	1.61	2.09	1.67	7.50	769	758	516	418
Mean	1.21	1.93	1.39	2.91	3.01	10.45	855	1066	505	508

Table 2. Influence of monthly precipitation on forage prooduction of crested wheatgrass ranges grazed at different seasons, Manitou Experimental Forest.

Grazing season	Significant precipitation	Equation number	Regression equation for forage production estimate	R^2	Standard error
Spring only	April (x_1)	(1)	$\hat{Y}_s = 533.32x_1 + 211.14$	0.88	185
Fall only	May (x_2)	(2)	$\hat{Y}_f = 198.90x_2 + 143.69x_4 + 263.96$	0.94	136
	July (x_4)				
Spring plus fall:					
Spring	April (x_1)	(3a)	$\hat{Y}_s' = 201.36x_1 + 266.95x_2 - 31.41$	0.97	56
	May (x_2)				
	April[1]	(3b)	$\hat{Y}_s' = 349.76x_1 + 200.00$	0.55	185
Fall	June (x_3)	(4)	$\hat{Y}_f' = 362.53x_3 + 66.93x_4 - 232.92$	0.87	126
	July (x_4)				

[1] Equation used for early estimate of forage yields for advance stocking rate information.

tion. Animals usually began grazing on spring-fall ranges in late April or early May; therefore, the ranges were stocked before the necessary production and precipitation data could be taken. To overcome this difficulty, Equation 3b was used to obtain an approximation of early forage yields for spring use on spring-fall ranges. This equation, based on April precipitation, accounted for only 55% of the variation in yield. It provides a conservative estimate of effective production.

Forage yields from crested wheatgrass grazed in the fall can be predicted well in advance. As shown in Equations 2 and 4 of Table 2, precipitation during May and July accounted for 94% of the variation in yields on ranges grazed only in the fall, and June and July precipitation accounted for 87% of the differences for fall yields on ranges grazed both spring and fall. With low standard errors of 136 and 126 lb/acre, respectively, each equation provides reliable estimates of fall forage yields from rainfall measurements.

Effect of Grazing Treatments on Plant Growth.—The monthly precipitation responsible for effective forage production at the different grazing seasons can be related to plant growth as it is influenced by harvesting. As shown below, when plants are grazed only at one season each year, leaf lengths (inches) when spring grazing began were about 0.5 inch longer than they were when plants were grazed at two seasons in the same year.

Grazing Treatment	Leaf Lengths
Spring	2.64
Fall	2.67
Spring-Fall	2.16

On ranges grazed only in the spring, the plants started rapid growth in April because of favorable moisture and associated warm weather. Much of their growth was completed during this month. They were then harvested by early June, but had the remaining summer months to grow and regain vigor. Plant growth during the latter part of the summer did not contribute to actual yield the following year, except that regained vigor allowed the plants to start rapid growth early the following spring.

Plants grazed only in the fall followed much the same development trend except that growth was delayed for a short time. Since the plants were grazed in the fall, the following April moisture was utilized primarily to initiate early plant growth, which contributed little in terms of total yield. Height growth and the bulk of the forage production was made during May, and some plant growth was added during July, which is usually wet.

Plants grazed both spring and fall needed April moisture simply to begin growth, and depended on May rainfall to continue rapid growth. After spring grazing, plants initiated additional growth in response to June precipitation, and added to this second-growth stage primarily from the rainfall in July.

Stocking Rates in Relation to Forage Production.—After forage production was estimated in relation to the precipitation received in certain months, the relationships between stocking rates and forage yields were determined by ordinary regression analysis. These stocking rates were closely associated with the amount of forage produced on each seasonal treatment. Correlation coefficients between stocking rates (y) and forage production (x) ranged from 0.94 to 0.99 (Fig. 1).

The pastures grazed both spring and fall provided the most grazing in terms of total yearling heifer days of grazing per acre. For example, at an expected forage yield of 800 lb, pastures grazed only in the spring would support 42.8 days of grazing and those grazed in fall 38.4. Pastures grazed both spring and fall, however, would support 52.9 days of spring grazing at 800 lb of forage plus 35.5 days of fall grazing with 800 lb of regrowth forage.

It was also possible through stepwise regression testing to estimate stocking rates directly from precipitation data. These analyses showed, for example, that on ranges grazed only in the fall, 95% of the variation in the number of yearling heifer days of grazing per acre was attributable to the rainfall received in May and July. This variation and the months accounting for it were almost identical to those for forage yields (Table 2, Equation 2).

Thus it would seem more direct to predict stocking rates from precipitation data. Such predictions may be appropriate where adequate information is available on production, precipitation, and stocking. However, because of differences between sites, plants, classes and kinds of livestock, and management objectives, a stocking-precipitation relationship from one area cannot be recommended for another area without proper testing. Since stocking is a direct function of effective forage production, and only an indirect function of precipitation, the two-step approach is suggested: (1) stepwise regression analysis to estimate effective forage yields, and (2) ordinary regression analysis to determine the particular stocking to be used. For many ranges, these data are already available.

Research Application.—In addition to its usefulness for management purposes, the statistical approach employed provides a tool for minimizing variation in research problems. For example, April-May precipitation in the present study was ineffective for making advance predictions of spring forage yields for stocking purposes on spring-fall ranges. The equation for these months did account for 97% of the variation in yields, however, and provided a means of removing variation due to environment in comparing forage yields between treatments. Also, total animal-days of use for experimental pastures could be predicted and the pastures then stocked accordingly to obtain the desired utilization in a specified period of time. This provides better control in grazing studies where variations in length of grazing periods are frequently a confounding factor in the analysis.

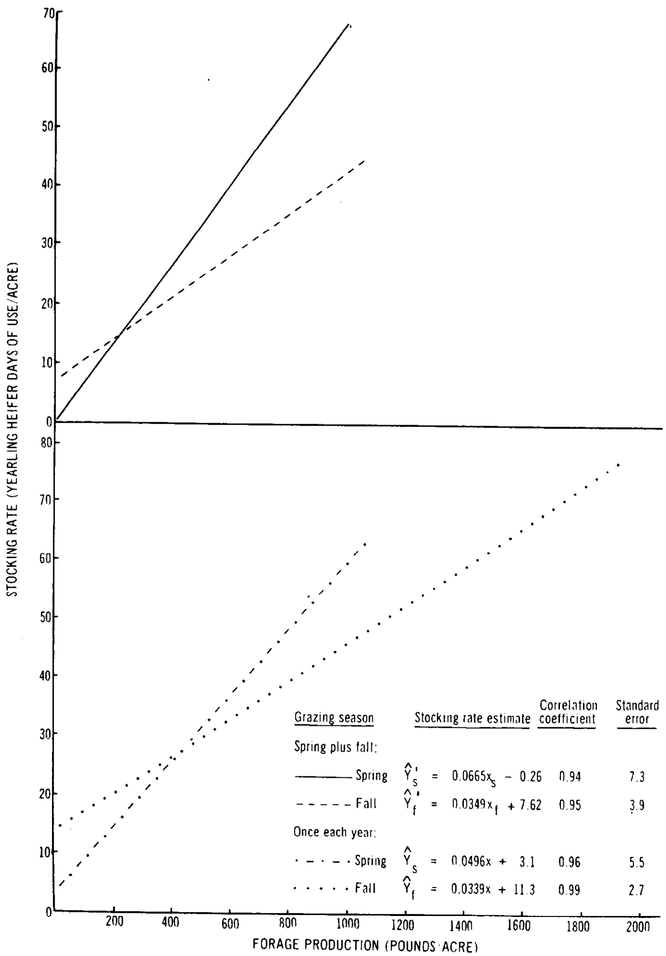

FIG. 1. Stocking rates in relation to forage production for crested wheatgrass grazed only in the spring, fall, or both spring and fall.

Summary

Stepwise regression analyses were made to determine how much influence monthly precipitation (x) during the growing season had on forage yields (y) of crested wheatgrass ranges grazed during spring, fall, and spring-fall seasons in the Front Range of Colorado. Precipitation accounted for 88 to 97% of the differences in yields, and the amounts received during dif-

ferent months or combinations of months determined the effective forage production available for use at each season. Precipitation in April primarily determined forage yields on ranges grazed only in the spring; for ranges grazed only in the fall, May and July rainfall was most useful for predicting yields. When ranges were grazed both spring and fall, April-May precipitation determined spring yields, and June-July moisture determined fall yields. Equations are given for estimating yields of crested wheatgrass grazed during these seasons.

Stocking rates in relation to forage yields during the different grazing seasons were also determined by ordinary regression analysis. Correlation coefficients between stocking rates (y) and effective forage production at each season (x) ranged from 0.94 for spring grazing on spring-fall ranges to 0.99 for ranges grazed only in the fall. It is suggested that comparable relations of production and stocking rates could be worked out from existing data for many of our rangelands. In addition to its use for predicting production from precipitation data, the method is also suggested as a means of accounting for variation in certain types of research studies.

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Seasonal and Growth Period Changes of Some Nutritive Components of Kikuyu Grass[1]

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Highlight

Changes in nutritive constituents of kikuyu grass with regrowth period and season were considered. The hemicellulose fraction of kikuyu grass collected during February and April contained xylose, arabinose, glucose, and galactose regardless of length of regrowth period. Protein decreased while fibrous components and lignin (72% sulfuric method) increased as regrowth was extended. The highest in vitro cellulose digestibility occurred at six weeks regrowth. Grazing rate or clipping practices should influence the value of kikuyu in feeding programs designed to produce acceptable beef from animals slaughtered directly from grass.

[1] *Approved by the Director of the Hawaii Agricultural Experiment Station as Technical Paper No. 797.*

Kikuyu grass (*Pennisetum clandestinum* Hochst. ex Chiov.), a native grass of tropical Africa, was introduced in Hawaii from California about 1924. Kikuyu has become one of the major range grasses on the island of Hawaii. The extensive use of this grass appears to be based on its resistance to trampling and grazing, ability to provide ground cover against undesirable brush and especially its ability to adapt to altitudes from sea level to over 5,000 ft. Much less is known, however, concerning the nutritive value of kikuyu grass for fattening cattle on pasture. This is an important consideration since the major portion of the beef produced by the State of Hawaii is grass-fattened only. The term "grass-fattening" as used in Hawaii would mean production of slaughter cattle directly off grass which grade at least high good at approximately two years of age.

Whitney et al. (1939) noted that ranchers were in disagreement as to the nutritive value of kikuyu. Younge and Otagaki (1958) indicated that kikuyu was among the grasses which were too low in protein to meet minimum standards for young growing cattle or for fattening cattle. Ishizaki (1963) showed kikuyu grass harvested in November and December to be of lower digestibility than panicum or paragrass (*Panicum purpurascens* Raddi) harvested during January, March, July, or August. Since the carbohydrates other than crude fiber have not been studied in detail, the potential of kikuyu grass in a grass fattening program with cattle remains in doubt.

The purpose of this study was to investigate the changes occurring in various nutritive constituents of kikuyu grass with regrowth periods during different seasons. The carbohydrates of the holocellulose fractions were given special consideration.

Methods

Samples of kikuyu grass were obtained from a 0.25 acre plot, 40 ft above sea level, located at the Waialua Livestock Research Farm on the northern (windward) side of the Island of Oahu. The soil, belonging to the Waialua Family (low humic latosol derived from alluvium), was very low in phosphorus and potassium, with a moderate level of calcium. The soil had a pH of 7.2 prior to planting or fertilization. The plot received approximately 100 inches of moisture annually, 30 inches in the form of rainfall and 6 inches monthly by irrigation. Four hundred lb/acre of 10-30-10 fertilizer was applied prior to each sampling series. Samples were collected after 4, 6, 8 and 10 weeks of regrowth during February and at 6, 8 and 10 weeks regrowth in April of 1964. Although yields were generally good, no 4-week regrowth collection was possible in April. Yields of grasses for the February collections were determined to be 3,006, 7,492, 15,333 and 14,636 lb/acre for the 4, 6, 8 and 10-week regrowth periods, respectively, and 6,795, 12,676 and 23,174 lb for the 6, 8 and 10 week-regrowth periods, respectively, for the April collections. All samples were hand cut approximately 2 inches above ground level, placed in plastic bags and stored at −20 C. until dried. The samples were dried in a forced air dryer at 65 C., ground in a Wiley Mill to pass a 40 mesh screen and stored at −20 C. in capped glass jars until analyzed.

Cellulose was determined by the method of Crampton and Maynard (1938). Holocellulose was prepared by the method of Whistler et al. (1948) using 5 g samples of forage. The cellulose and hemicellulose components of holocellulose were separated and isolated according to the procedure of Myrhe and Smith (1960). Following acid hydrolysis of a 1 g sample of hemicellulose (Myrhe and Smith, 1960), the neutral sugars were separated on Whatman 3MM filter paper using a butanol-pyridine-water (6:4:3: v/v) solvent system. Duplicate 25 lambda applications of each sugar were spotted on the paper from a 10 cc solution of the syrup hydrolysate. After a 32-hr irrigation period, the chromatograms were removed and dried at room temperature. Only one of a duplicate set of chromatograms was sprayed with aniline hydrogen phthalate (Partridge, 1948) to locate the separated sugars. Each sugar was eluted from the unsprayed counterpart with 10 cc distilled water and determined quantitatively by the phenol and sulfuric acid method recommended by Dubois et al. (1956). Protein and crude fiber were analyzed by the method of the A.O.A.C. (1960). Acid-detergent fiber and lignin (Van Soest, 1963) and lignin (Patton, 1943) was also determined on all kikuyu grass collections. Forty-eight hour in vitro cellulose digestibility determinations were made according to the method of Kamstra et al. (1958).

Results

Interrelationship of Fibrous Components, Crude Protein and Lignin.—As indicated in Table 1, the fibrous components of kikuyu grass as represented by crude fiber, detergent fiber, cellulose, hemicellulose and holocellulose were affected by period of regrowth and seasons. As shown in Table 2, the crude protein decreased with regrowth interval during the December to February and February to April regrowth periods. Holocellulose and hemicellulose increased with regrowth during the December to February period and all fibrous fractions, except crude fiber, increased during the February to April regrowth intervals. Lignification increased with regrowth during the two collection periods as indicated by the 72% sulfuric acid method. No consistent increase in lignin was demonstrated by the acid-detergent method during the December collection. Many workers have demonstrated that lignin, crude fiber or cellulose increase and crude protein decrease as plants mature (Patton, 1943; Kamstra et al., 1958; Quicke and Bentley, 1959). These and other authors suggest increase in lignin as a cause for decreasing plant digestibility with approaching maturity. Kikuyu grass cellulose also shows decreasing digestibility with maturity especially after 6 weeks regrowth (Fig. 1). This could be a reflection of an increase in lignin along with a decrease in protein. It must be

Table 2. Lignin and protein content of kikuyu grass, 1964.

Growth period (weeks)	Cut. date	% of plant, dry basis SA[1] lignin	AD[2] lignin	Crude prot.
4	2-12	9.7	5.9	11.8
6	2-12	10.2	5.2	9.7
8	2-12	11.6	5.6	8.6
10	2-12	12.4	4.0	7.3
6	4- 1	14.1	3.4	11.8
8	4-15	15.8	3.7	9.4
10	4-29	16.9	4.8	6.8

[1]SA=72% sulfuric acid lignin.
[2]AD=Acid-detergent lignin.

Table 1. Fibrous fractions of kikuyu grass as determined by various methods, 1964.

Growth period (weeks)	Cutting date	Percent of plant on dry basis: Crude fiber	Detergent fiber	Cellulose	Holo-cellulose	Hemi-cellulose
4	2-12	27.1	38.8	33.4	67.4	30.3
6	2-12	28.7	38.1	32.5	67.9	35.6
8	2-12	30.2	40.5	34.5	69.6	36.6
10	2-12	30.3	37.4	36.5	72.8	36.8
6	4- 1	28.3	35.3	34.9	68.5	29.6
8	4-15	31.6	37.6	35.4	72.1	32.7
10	4-29	34.2	39.5	36.2	76.6	39.2

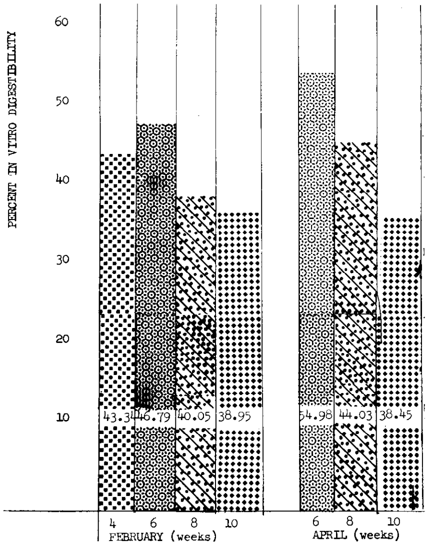

FIG. 1. Seasonal and regrowth changes in *in vitro* cellulose digestibility of kikuyu grass.

noted, however, that cellulose digestibility was higher for the 6 and 8-week regrowth periods in April than for similar periods in February even though lignification (72% sulfuric method) was higher in April. Perhaps differences in hemicellulose composition could also account for changes in digestibility or feed value as suggested by Myrhe and Smith (1960).

Neutral Sugar Components of the Hemicellulose Fraction. — The hemicellulose fractions of all regrowth stages during each collection period, upon hydrolysis, produced the neutral sugars xylose, arabinose, glucose, and galactose in order of decreasing concentration. The percentage composition of each sugar comprising the hemicellulose hydrolysate varied with growth period and season (Fig. 2). The greatest proportion of xylose in hemicellulose occurred during the eighth week of regrowth in each cutting series during February and April. Arabinose, glucose, and galactose were at their lowest levels during this period. In samples taken two weeks later, however, xylose reached its lowest concentration with arabinose and glucose at maximum levels (Fig. 1). Schentzel (1963) showed a progressive increase in the xylose and glucose content of western wheatgrass hemicellulose from June through August with a sharp decline in September. Sullivan et al. (1960) noted a marked decrease in glucose with the approach of maturity in grasses.

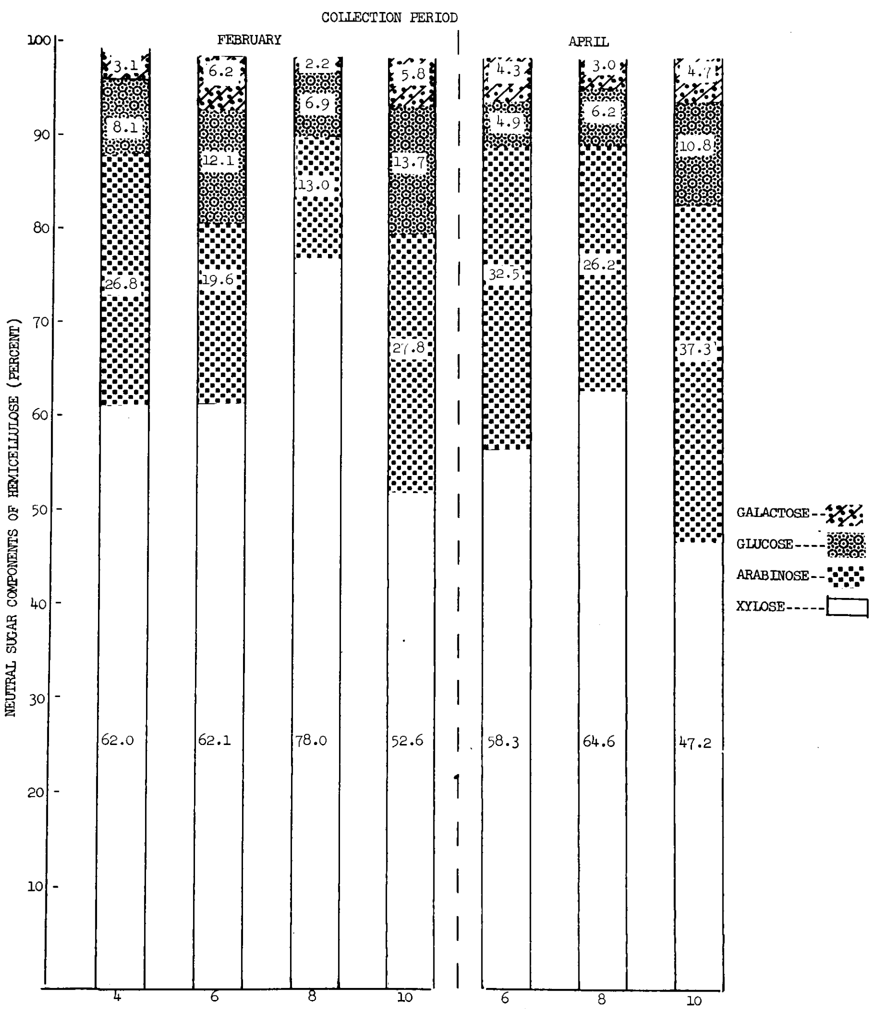

FIG. 2. Seasonal and regrowth changes in the neutral sugar components of kikuyu grass.

The sugar composition of hemicellulose which would provide maximum palatability and energy for animals has not been ascertained. The determination of the season and growth period at which the total carbohydrate content of the plant is high should be of assistance in developing a grass-fattening program for ruminant animals. It would not be sufficient, however, to consider only plant carbohydrate since other plant components such as lignin may prevent efficient utilization by animals. Factors such as altitude, soil type, or plant height may also affect plant metabolism. For example, Hosaka (1958) noted that seed production in kikuyu grass was frequent only at elevations of 3,000 ft or more. Edwards (1937) suggests that flowering in kikuyu is not usual in longer herbage.

Summary and Conclusions

A composition study was made with regrowths of kikuyu grass collected in February and April. Fibrous components, lignin and neutral sugars comprising the hemicellulose fractions were considered. Comparative 48-hour in vitro cellulose digestions were determined for each regrowth period.

Both the length of regrowth period and seasonal effects on composition were indicated. Protein decreased and fibrous compounds increased with the length of regrowth in forage collected in February and April. Cellulose digestibility was highest after 6 weeks of regrowth, then decreased at each regrowth period. The hemicellulose fractions of all collections contained xylose, arabinose, glucose and galactose. Xylose accounted for the greater proportion of the sugars and its concentration increased up to 8 weeks of kikuyu regrowth regardless of collection date. It would appear that the hemicellulose sugars found in the tropical kikuyu grass are also present in the grasses growing in more temperate climates although the relative concentrations of individual sugars with growth period and season may well be different. Temperate climates provide seasonal resting or dormant periods for grasses whereas the seasons of the Hawaiian Islands are marked only by changes in the length of daylight, moisture and minor temperature variations. Under such a continuous growing regime, range grasses including kikuyu could be subjected to year-long grazing. Proper grazing or clipping practices, fertilization, and periodic resting should increase the value of this grass. Considering its digestibility and composition, a rotation grazing system allowing 6 to 8 weeks of rest for regrowth followed by a short period of close grazing or mowing would be suggested for maximum utilization. Kikuyu has a tendency to become woody and matted if allowed to mature and even the less mature forage is considered to be of only medium palatability (Hosaka, 1957). Mixing legumes with kikuyu pasture would compensate for any lack of protein. Ranchers criticize kikuyu for being too aggressive in mixed-grass pastures. Proper management and more knowledge concerning its nutritive potential at any particular growth period or season should reaffirm kikuyu as an important range grass, especially for areas not suited for other grasses or where weed control is difficult.

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Cleistogenes in *Danthonia*[1]

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Highlight

Cleistogamy is the behavior of flowers which do not open but which produce fruits and seeds as a result of self-fertilization. *Danthonia californica, D. unispicata,* **and** *D. spicata* **were found to be cleistogamous, but** *D. intermedia* **produced no cleistogenes in Jackson Hole, Wyoming. Cleistogenes were capable of producing new plants and therefore may be a means for reproduction for cleistogamous species in Jackson Hole.**

Cleistogamy is understood to be the behavior of flowers which do not open but which produce fruits and seeds as a result of self-fertilization. Cleistogamy (literally closed marriage) results in a type of fertilization called autogamy. More simply, cleistogamy refers to florets that never open, making cross-pollination impossible. In many chasmogamous (open-pollinated) flowers self-pollination occurs, but the possibility of cross-pollination is always present.

Investigations and descriptions of cleistogamy date back to the year 1539 (according to Uphof, 1938), when Hieronymus Bock mentioned in his publication, "Neue Kreuter Buch," on barley, that some grasses were able to produce fruits without showing the various parts of the flowers. Linnaeus (1753) also was conscious of this closed flower condition as determined from his description of *Panicum clandestinum,* published in "Species Plantarum."

In the study of cleistogamy in grasses one of the most difficult problems is that of definitions. The majority of grasses in which cleistogamy occurs have both chasmogamous flowers and either one or two types of cleistogamous flowers. When the cleistogamous florets are born on the terminal panicle but show strong differences (usually in another size or loss of lodicules), the plants are called dimorphic.

According to Arber (1934), "Cleistogamic inflorescences sometimes take the minimal form of 'cleistogenes'—solitary, sessile, single flowers, with lemma and palea, but without the usual outer empty glumes." These cleistogenes occur in the lower leaf-sheaths of the flowering culms or in the axils of the lower branches. Two or three-flowered spikelets may be involved. The cleistogamous florets characteristic of *Amphicarpon* and *Chloris chloridea* are of the same order as cleistogenes, but since they are born on underground culms they would seem to need a separate term. Since none has previously been used it is suggested that they be called rhizanthogenes (or rhizanthogames). In all cases where at least two types of cleistogamous florets occur on the same plant, the plants are referred to as amphigamic.

In some cases it would appear that cleistogenes disperse with difficulty, especially when the basal sheaths are persistent and the flowering culms are not dehiscent. However, there is a tendency for an association between the presence of cleistogamous spikelets and dehiscent inflorescences (e.g., *Danthonia, Sporobolus, Scleropogon),* which sometimes aids in cleistogenic dispersal. Perhaps more important than dispersal is their formation under severe overgrazing, allowing for reproduction (cf. Dyksterhuis, 1945).

Phylogenetically, the distribution of cleistogenes is interesting. Perhaps there is significance in the apparent absence of this character from such characteristic and well-known festucoid tribes as the Festuceae, Aveneae, Phalarideae, Agrostideae, and Hordeae. This emphasizes the mesophytic northern origin of the festucoid group in contrast to the arid southern dispersals so characteristic of the species and tribes in which cleistogenes are present, e.g., Stipeae *(Stipa leucotricha),* Sporoboleae *(Sporobolus vaginiflorus,)* Eragrosteae *(Leptochloa dubia),* Danthoneae *(Danthonia unispicata),* and Pappophoreae *(Cottea pappophoroides).*

The phylogenetic relationships among the above tribes are sufficiently diverse to leave open the question as to whether the presence of cleistogenes is an example of epharmonic development. Cleistogenes are not characteristic only of North American arid areas. They occur also in all other arid areas of the globe. They may occur in these places in the same species when it is able to bridge the gap (e.g., Parodi reported that in South America *Enneapogon desvauxii* bears cleistogenes), or sometimes is related species (e.g., Chase reported that in the Old World *Pappophorum boreale* and *P. brachystachyum* bear cleistogenes).

Cleistogene formation is, within bounds, an epharmonic development in grasses. The cases of facultative cleistogamy are probably very numerous and seldom reported. They represent an evolutionary tendency throughout the grass family. Dimorphic cleistogamy is more often reported but also shows closer association with plants occurring in warm, arid areas. Cleistogene formation is the most restricted (1) in number of tribes in which it occurs, (2) in number of species in which it occurs, and (3) in geographic area.

Danthoneae

Primitive distributions in the Gramineae are primarily tropical or subtropical, e.g., those of the tribes

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Bambuseae, Olyroideae, and Oryzeae. The groups second most primitive, at least in evolutionary origin and distribution pattern, are those which are most abundant in the southern hemisphere and are lacking at high altitudes in the northern hemisphere; e.g., Danthoneae is one of the more recently accepted tribes of the Gramineae, the recognition of which has done much for the understanding of naturally drawn borders around the remaining tribes.

Danthoneae are now more abundant in temperate regions. More species survive in the southern hemisphere than in the northern. The history of Danthoneae distribution must be presumed to be early, to have involved the same southern routes which were taken by the tropical groups, but, on the other hand, to be independent of the parallelism found in the Bambuseae, Olyroideae and Oryzeae. *Anisopogon* supplies the geographical link between South Africa and Australia. Two genera are found in India *(Danthonidium* and *Hubbardia)*, *Notochloe* in Australia, and *Monostachya* occurs in the Philippines and New Guinea. However, the bulk of the genera and species of the Danthoneae are African, e.g., *Schismus* (annuals now introduced in the New World), *Plagiochloa, Asthenatherum, Pentaschistis, Pentameris, Afrachneria, Chaetobromus, Urochlaena, Lasiochloa, Prionathium, Alloechaete, Phaenanthoecium,* and *Poagrostis*. The New Zealand flora includes *Chionochloa, Notodanthonia, Erythranthera* and *Pyrrhanthera*.

Danthonia

Danthonia shows marked disjunction in range of its species. Temperature regions have species concentrations in South Africa, south Australia and New Zealand, South America, and finally North America. The Eurasian continent is the poorest in representation with one species in the Mediterranean region *(D. provincialis)* and two in the Himalaya Mountains *(D. cachemyriana* and *D. jacquemontii)*. Except for occurrence of *Danthonia californica* var. *americana* on the western coastal regions of North America and South America, the species are endemic to their areas. However, in North America four centers of distribution occur: Mexico *(D. filifolia)*, the Caribbean Sea *(D. domingensis* and *D. obtorta)*, the Rocky Mountains *(D. parryi, D. unispicata)*, and eastern North America *(D. compressa* and *D. sericea)*. *Eastern North* America and the Rocky Mountains are related to each other by two similarly disjunct distributions in *D. spicata* and *D. intermedia*.

In South America another four centers of distribution occur, the Andes (four or five species are well-known species, but 17 scientific names are based on types from here), the delta region of the Parana (two species), subtropical Brazil (about five names but little known about the species), and finally the paramos of Venezuela, Ecuador and Brazil *(D. secundiflora)*.

The North and South American species are as strongly related to each other as they are to any of the Old World types. This leads to the conclusion that they arrived in the New World at one time. That the North American species were derived from the South American and dispersed across the tropics is suggested by (1) absence of Arctic and subarctic species, (2) absence of the genus from northern Europe and Asia, (3) presence of its distribution to the tip of South America, (4) its presence in the tropics of Brazil, the islands around the Caribbean Sea, and in central Mexico, (5) strong representation of a diploid chromosome number of 36 in both regions, (6) presence of cleistogamous types in both regions, (7) presence of the types with bicellular hairs and dumbbell-shaped siliceous cells as a characteristic part of the leaf anatomy in all areas.

Cleistogenes in *Danthonia*

This report contains information on *Danthonia* in the Jackson Hole area of Wyoming. It is designed to show (1) which species display a cleistogamous condition, (2) cleistogene location, attachment, and number on the cleistogamous species, (3) nodal disarticulation occurrence, and (4) germination of cleistogamic and chasmogamic seeds.

Four species of *Danthonia* occurring naturally in the flora of Jackson Hole, Teton County, Wyoming, furnished the basic materials. These species are *D. spicata, D. unispicata, D. intermedia,* and *D. californica*. In addition, *D. parryi* was collected from Pole Mountain in the Medicine Bow National Forest near Laramie, Albany County, and transplanted on the Biological Research Station at Moran for comparative studies.

Cleistogene Location, Attachment, and Number.—Early in the growing season, cleistogenes are not readily evident. Dissection shows that these small seeds originate at the joints of the flowering culms and are wrapped by the base of the sheaths. Later in the growing season, cleistogenes appear as small bumps which can be seen plainly at joints where they occur (Fig. 1).

D. spicata is characteristically a monocleistogamous species with seldom more than one cleistogene at a joint. Each small seed, enclosed in a lemma and a palea, seems to be sessile. The prophyllum is present in the form of two indurate, wing-like structures which occur at the point of attachment.

D. californica and *D. unispicata* are termed polycleistogamous, since more than one cleistogene occurs at each joint on the flowering culm. Both of these species produce cleistogenes which are enclosed in a lemma and a palea. The cleistogenes are borne on a rachilla which arises at the base of the lowermost cleistogene and serves as a means of attachment for the others. The basal cleistogene in these two species has the characteristic indurate, wing-like structures; but cleistogenes produced on the terminal portion of the rachilla lack these appendages.

The cleistogamous condition is easiest to recognize in *D. californica*. This species produces a maximum of eight cleistogenes at each node of the flowering culm, and, late in the growing season, the terminal cleistogenes protrude from the sheath. *D. unispicata* produces 2 to 3 cleistogenes at a node, but seldom do they extend beyond the upper portion of the sheath until the flowering culm has dehisced from the plant.

A smaller number of cleistogenes is produced per node in the terminal portion of the flowering culms in the species *D. unispicata* and *D. californica*. Although there may be the same number of lemmas and paleas at each node, the cleistogenes are definitely smaller and more likely to be rudimentary.

Weatherwax (1928) compared cleistogenes and chasmogamous seeds produced in the inflorescense as follows:

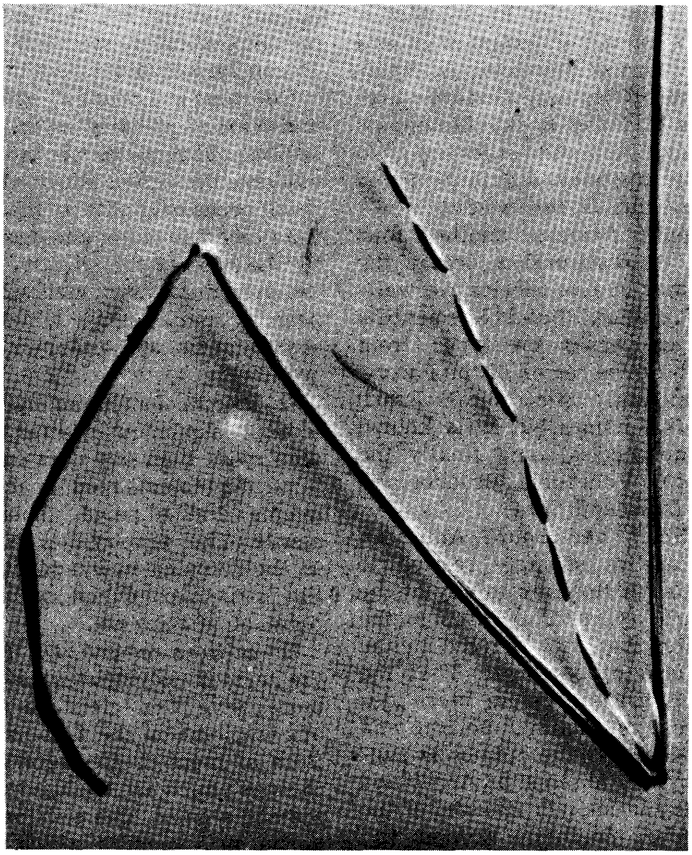

FIG. 1. Node and internode from *Danthonia californica* showing cleistogene location, attachment, and number.

"In some cases, the two types of disarticulated florets differ greatly in appearance because of the variable nature of the lemma; but there seems to be no consistent difference in the caryopsis. Seeds from both sources germinate alike; and seedling plants observed until flowering, the second season after germination, are alike in appearance and vigor." Table 1 illustrates the number of cleistogenes produced in the cleistogamous species with the number of seeds produced in these same plants. *D. unispicata* and *D. californica* produce more cleistogenes than chasmogamous seeds. Cleistogene production in *D. spicata* is relatively low compared with the chasmogamous seeds.

Cleistogenes on *D. unispicata* are larger and sometimes twice the size of chasmogamic seeds (Fig. 2).

Size differences also are characteristic of *D. californica*. Since this species produces as many as eight cleistogenes per joint, many of the terminal ones are somewhat shorter than the seeds from the inflorescence. Basal cleistogenes are longer and, in general, larger than the chasmogamic seeds. In *D. spicata*, cleistogenes and chasmogamic seeds have close resemblance, and it was difficult to determine which were produced at the joints and which from the normal inflorescence.

Nodal Disarticulation.—Disarticulation or breaking of the flowering culm at each joint occurs in the three cleistogamous species of *Danthonia* at different times during the stages of growth. This breaking occurred just below each node, the basal ones being the first to fall. Actual separation of the terminal internodes occurred after the flowering culm had fallen from the plant. Each segment of the flowering culm was composed of the internode, basal node, the sheath, and the cleistogenes. At this stage of maturity the sheath was starting to loosen; thus all the cleistogenes may not have been present.

D. unispicata was the first of the cleistogamous species to begin nodal disarticulation. In late July and early August the flowering culms

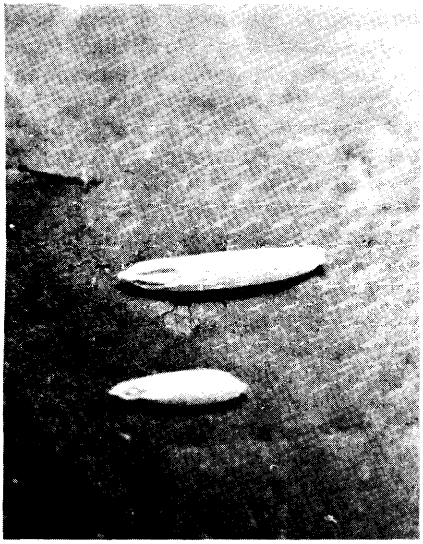

FIG. 2. A comparison in the size of seeds produced in the normal inflorescence (lower caryopsis) of *Danthonia unispicata*, and cleistogenes produced at the nodes (upper caryopsis).

Table 1. Comparison of chasmogamic seed production with cleistogene production among four *Danthonia* species.[1]

Species	*D. unispicata*	*D. spicata*	*D. intermedia*	*D. californica*
No. spikelets per flowering culm	1	5-6	7-8	3-4
No. florets per spikelet	4-5	5-6	3-4	5-6
No. nodes with cleistogenes	3-4	2	none	5-6
No. cleistogenes per node	2-3	1	none	6-7
Total no. seeds per flowering culm	4-5	27-28	25-26	21-33
Total no. cleistogenes per flowering culm	8-9	2	none	25-36

[1] Means based on 100 flowering culms of each species.

were scattered at the base of the plant. Lack of culms gave the plant a naked look because only basal leaves remained. At this time of year, the appearance of the plant is very much the same as it was in the spring before any flowering culms were produced. Just before nodal disarticulation occurred, the flowering culms turned a reddish color, which made *D. unispicata* easy to locate. Evidently, when the red color first appeared, the nutrient supply to the flowering culms had been discontinued because of the separation of the first joint from the base of the plant, and curing the grass had started.

Internodes containing only a portion of the stem and the sheath were found scattered and intermingled among the plants in the locality of *D. unispicata*, particularly when game or livestock had been present.

D. californica disarticulated in the same manner as *D. unispicata* except that the entire plant was more mature before this process began. Joints did not break into separate entities as easily in *D. californica*, and the entire culm remained united with the inflorescence until long after the flowering culm had disarticulated at the basal node. This breaking up first occurred approximately in the middle of August.

Nodal disarticulation of *D. spicata* occurred so late in the growing season (September 1 to 15) that we doubt whether such disarticulation might have any effect on the distribution and scattering of chasmogamic or cleistogamic seeds. The fact that *D. spicata* produced only a few cleistogenes in addition to the late, and only partial, nodal disarticulation of the flowering culms may indicate that it is more closely related to the two North American species, *D. intermedia* and *D. parryi*. Both of these species also occurred in Wyoming, but only *D. intermedia* was present in Jackson Hole. Neither displayed nodal disarticulation.

Germination.—The purpose of the germination tests was to determine whether cleistogenes are viable, and how their percentage germination compared with that of chasmogamic seeds which were taken from the same plant. Observations during the early part of the growing season showed many small seedlings clustered around the base of each parent plant of *D. unispicata* (Fig. 3). How many of these small plants were produced by cleistogenes and how many from chasmogamic seeds was impossible to determine in the field. However, seedling abundance suggests that cleistogenes are an important means of reproduction for at least this cleistogamous species of *Danthonia* in Jackson Hole.

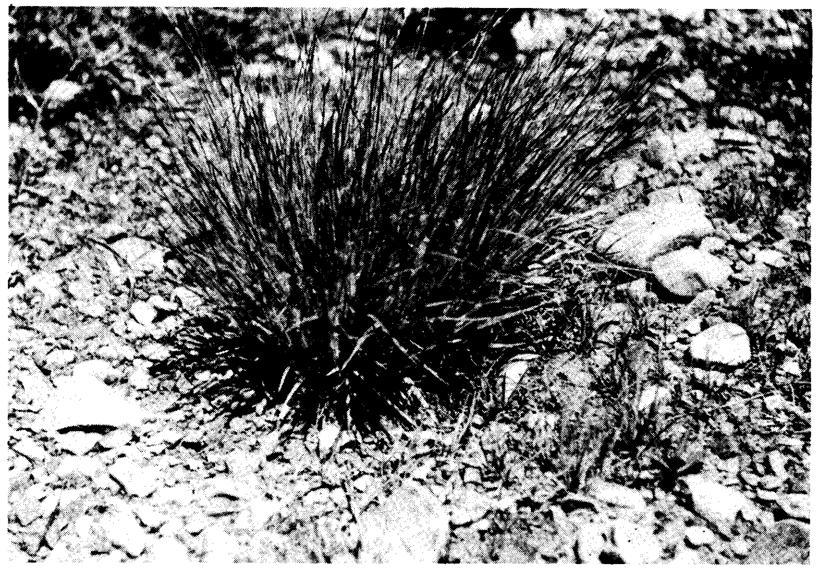

Fig. 3. Small seedlings of *Danthonia unispicata* showing their abundance and clustered distribution around the parent plant.

Table 2. Comparison of percentage germination of chasmogamic seeds and cleistogenes under various treatments.

Species	Type of seed	Treatment	Percentage germination
D. unispicata	Cleistogamic	Water and chilled	41
	Chasmogamic	Water and chilled	40
	Cleistogamic	Water and non-chilled	66
	Cleistogamic	KNO_3 and non-chilled	66
D. californica	Cleistogamic	Water and chilled	0
	Chasmogamic	Water and non-chilled	0
	Cleistogamic	Water and non-chilled	0
	Cleistogamic	KNO_3 and non-chilled	10
	Chasmogamic	KNO_3 and non-chilled	10
D. spicata	Cleistogamic	Water and chilled	70
	Chasmogamic	Water and chilled	33
D. intermedia	Chasmogamic	Water and chilled	95

Cleistogenes from the three species, *D. spicata, D. unispicata,* and *D. californica* proved to be viable and capable of producing new plants. There was a wide range in germination percentage of the cleistogamous species (Table 2). *D. californica* cleistogenes germinated only when the blotters had been soaked with potassium nitrate. Cleistogenes of *D. spicata* had the highest percentage (70%), with those of *D. unispicata* second (66%).

D. intermedia displayed the highest germination percentage of chasmogamic seeds while *D. californica* had the lowest percentage germination when both chasmogamic seeds and cleistogenes were compared. This may partially explain the limited distribution of this species in the Jackson Hole area. Cleistogenes in the other two cleistogamous species of *Danthania* compared favorably with the germination of chasmogamic seeds.

The potassium nitrate treatment was the only condition under which both types of seeds from *D. californica* germinated. Therefore it is possible that certain elements in the soil can affect germination of this species.

Plants from the germinated cleistogenes and chasmogamic seeds were transplanted into pots in the greenhouse. After two months there appeared to be no difference in appearance and vigor of the two kinds of seedlings.

Summary and Conclusions

D. californica and D. unispicata were found to be polycleistogamous with more than one cleistogene produced at each joint, and all attached by an axis or rachilla. *D. spicata* was found to be monocleistogamous, producing only one cleistogene per joint and often only one joint at the base of the flowering culm had a cleistogene present. *D. intermedia* produced no cleistogenes in Jackson Hole.

Cleistogenes were more abundant per flowering culm than were the chasmogamic seeds in the two species *D. unispicata* and *D. californica.*

Nodal disarticulation occurred in the three cleistogamous species and proved to be a means by which cleistogenes and chasmogamic seeds were scattered, particularly in the localities of *D. californica* and *D. unispicata.*

Cleistogenes were found to be capable of producing new plants and therefore are described as a means of reproduction for the cleistogamous species in Jackson Hole.

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Range Reseeding Success on The Tonto National Forest, Arizona

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Highlight

Longevity of range plantings is important to those interested in range restoration by this means. An analysis of plantings of 1945 and 1946 through 1965 provide information on longevity for four different environments on the Tonto National Forest of central Arizona. Protective brush mulch was highly important for stand establishment under the conditions of these tests.

Many rangelands in Arizona can be benefited by reseeding to perennial grass. A basic consideration for reseeding is the discovery of long-lived, palatable and otherwise adaptable species. This study reports on perennial grasses that have survived 16 years or more under arid conditions on the Tonto National Forest of central Arizona. Planting trials, methods, and longevity of species are appraised for four different growing conditions.

Revegetation of range lands in Arizona, as elsewhere, was an early undertaking of research. Griffiths (1907) concluded that reseeding on an economic basis is applicable to those areas where requisite moisture occurs. Sampson (1913) and Glendening (1937a, 1937b, 1938) stressed the importance of soil treatment, covering seed and protecting seeded areas until establishment occurred. Glendening (1937c) advocated the use of mulch to establish stands. Cassady (1937) listed general suggestions on reseeding incorporated in the original plans. Crider's (1945) evaluation of the three introduced lovegrasses proved of value in deciding where each species was used. This report supplements the preliminary publication by Judd (1948) on this study.

Study Areas

The Tonto National Forest of 2,960,567 acres is located in central Arizona. It includes the

Sierra Ancha, Mazatzal, and Superstition mountain ranges, as well as parts of the watershed basin of the Salt River. Much of the mountain country supports forests of ponderosa pine *(Pinus ponderosa* Lawson), Douglas fir *(Pseudotsuga menziesii* (Mirb.) Franco), and white fir *(Abies concolor* (Gord. & Glend.) Lindl.); lower, semi-desert country includes areas of brush or grass covered foothills. This more open country is in the Tonto Forest at the request of the U.S. Reclamation Service for protecting the Salt River Valley Irrigation Project.

Four principal planting sites, each representative of a major ecological situation on the Tonto Forest, were chosen for study (Fig. 1). These sites were: Black Hill, Cave Creek, Pine Creek (near Young), and Buckhead Mesa between Payson and Pine.

F. Lee Kirby, former supervisor, Tonto National Forest, initiated this reseeding program in 1945, with the author in charge of the project. Personnel of the Rocky Mountain Forest and Range Experiment Station, U.S. Forest Service, and the Soil Conservation Service assisted with the project plans.

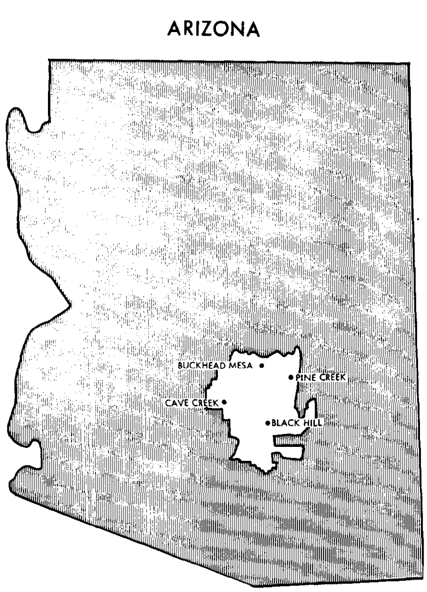

FIG. 1. The four revegetation sites on the Tonto National Forest, central Arizona.

I wish to express deep appreciation to Hudson G. Reynolds and Fred Lavin for reviewing the manuscript and offering many helpful suggestions.

Black Hill

Environment. — This area is about 1.5 miles south of the Salt River arm of Roosevelt Lake and some 6 miles southeast of the town of Roosevelt. It is occupied principally by mesquite *(Prosopis juliflora* (Swartz) D.C.), catclaw acacia *(Acacia greggii* A. Gray), paloverde *(Cercidium* spp.) and spiny hackberry *(Celtis pallida* Torr.). In the early spring there is usually a dense covering of woolly indianwheat *(Plantago purshi* Roem. & Schult.) with some annual grasses. The elevation is approximately 2,100 feet. Although the precipitation varies annually from 8.31 to 25.08 inches and is highly erratic, the average annual total is about 16 inches. Fig. 2 shows mean monthly temperature distribution. This site represents a difficult environment to reseed because of low temperatures, high temperatures and evaporation rates, and surface-sealing of soils.

Methods. — The large plots were generally 1 x 2.5 chains in size and were replicated and randomized in a modified Latin square in so far as possible. Strip plots were 1/6 x 2.5 chains.

In 1945, planting methods tested were: disk-broadcast seed-cultipack-mulch with native brush; disk-broadcast seed-cultipack; disk-broadcast seed-harrow; broadcast seed-disk; broadcast seed-harrow; and broadcast seed without site preparation. In 1946 half of the 1945 seedings were replanted; an additional 21 range species tested in replicated mulched row plantings. All plantings were made in June. Species planted by various methods are listed in Table 1.

Germination and survival.— By September 1945, Boer and Lehmann lovegrasses, bush muhly and hooded windmillgrass had emerged in plots which were disked and cultipacked. Plains bristlegrass and the Rothrock grama had emerged well in row plantings.

By 1946 the only survival was under the brush mulch. Plots

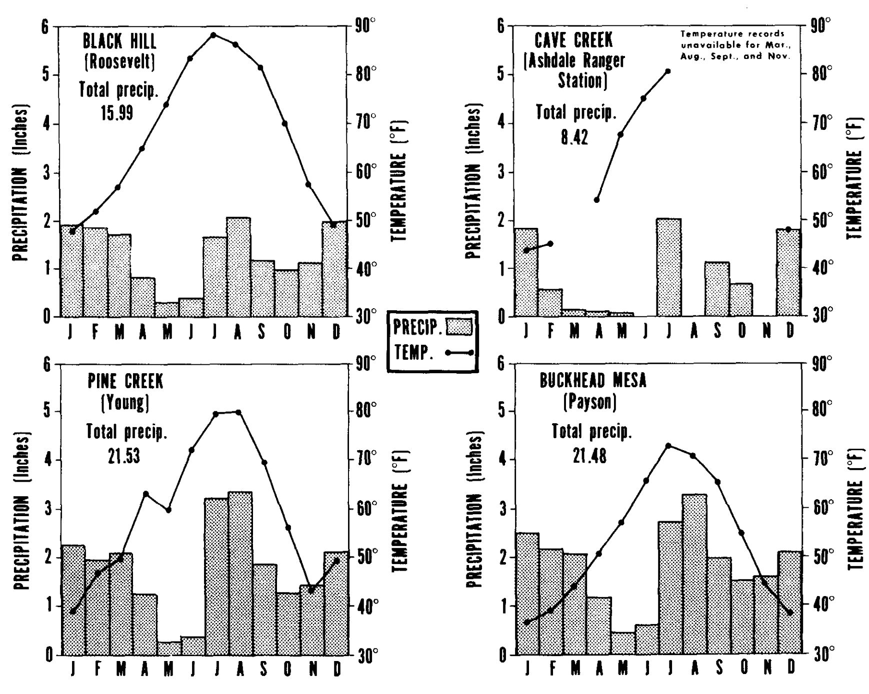

FIG. 2. The average monthly precipitation and mean temperatures for the four study plots.

Table 1. List of species used by study area and method.

Common name	Scientific name	Black Hill 1945-1946		Cave Creek 1945-1946		Pine Creek 1945-1946		Buckhead Mesa 1945-1946		Plot	Row
GRASSES AND GRASSLIKE PLANTS											
Crested wheatgrass	*Agropyron desertorum* (Fisch.) Schult.			X	X	X		X		X	
Intermediate wheatgrass	*A. intermedium* (Host) Beauv.						X		X		X
Western wheatgrass	*A. smithii* Rydb.			X		X		X		X	
Pubescent wheatgrass	*A. trichophorum* (Link) Richt.						X		X		X
Cane bluestem	*Andropogon barbinodis* Lag.	X	X		X					X	X
Turkestan bluestem	*A. ischaemum* L.					X	X	X		X	X
Little bluestem	*A. scoparius* Michx.					X		X		X	X
Curly mitchellgrass	*Astrebla lappacea* (Lindl.) Domin.	X	X		X					X	X
Sideoats grama	*Bouteloua curtipendula* (Michx.) Torr.					X	X	X		X	X
Black grama	*B. eriopoda* Torr.			X			X	X		X	X
Slender grama	*B. filiformis* (Fourn.) Griffiths			X	X				X	X	
Blue grama	*B. gracilis* (H.B.K.) Lag.					X		X		X	X
Hairy grama	*B. hirsuta* Lag.			X			X			X	X
Rothrock grama	*B. rothrockii* Vasey	X	X		X						X
Smooth brome	*Bromus inermis* Leyss.						X		X		X
Indian sandbur	*Cenchrus biflorus* Roxb.		X		X						X
Hooded windmill grass	*Chloris cucullata* Bisch.	X			X					X	
Uruguay chloris	*C. berroi* Arech.		X		X						X
Bicolor lovegrass	*Eragrostis bicolor* Nees		X		X						X
Boer lovegrass	*E. chloromelas* Steud.	X	X	X	X					X	X
Weeping lovegrass	*E. curvula* (Schrad.) Nees	X	X	X	X	X	X	X		X	X
	E. echinochloidea Stapf.		X		X						X
Plains lovegrass	*E. intermedia* Hitchc.						X		X		X
Lehmann lovegrass	*E. lehmanniana* Nees	X	X	X	X		X			X	
Wilman lovegrass	*E. superba* Peyr.		X								X
Sand lovegrass	*E. trichodes* (Nutt.) Wood						X		X		X
Tanglehead	*Heteropogon contortus* (L.) Beauv.						X		X		X
Curlymesquite	*Hilaria belangeri* (Steud.) Nash			X						X	
Wolftail	*Lycurus phleoides* H.B.K.						X		X		X
Bush muhly	*Muhlenbergia porteri* Scribn.	X								X	X
Deergrass	*M. rigens* (Benth.) Hitchc.					X	X	X		X	X
Smilograss	*Oryzopsis miliacea* (L.) Benth. & Hook.						X		X		X
Blue panicgrass	*Panicum antidotale* Retz.			X						X	
Vinemesquite	*P. obtusum* H.B.K.						X	X	X		X
Sand paspalum	*Paspalum stramineum* Nash		X		X						X
Buffelgrass	*Pennisetum ciliare* (L.) Link		X		X						X
Plains bristlegrass	*Setaria macrostachya* H.B.K.	X									X
Sand dropseed	*Sporobolus cryptandrus* (Torr.) A. Gray	X	X	X	X					X	X
White tridens	*Tridens albescens* (Vasey) Woot. & Standl.				X	X	X	X	X	X	X
Rough tridens	*T. elongatus* (Buckl.) Nash			X				X	X	X	X
Slim tridens	*T. muticus* (Torr.) Nash	X	X		X	X	X			X	X
Arizona cottontop	*Trichachne californica* (Benth.) Chase	X									X
SHRUBS											
Fourwing saltbush	*Atriplex canescens* (Pursh) Nutt.		X		X		X		X		X
Spiny saltbush	*A. confertifolia* (Torr. and Frem.) S. Wats.		X		X						X
Showy menodora	*Menodora longiflora* A. Gray		X		X						X
Rough menodora	*M. scabra* A. Gray		X		X						X
Broom menodora	*M. scoparia* Engelm.		X		X						X
Australian sheepbush	*Pentzia incana* (Thunb.) O. Kuntze		X		X						X
Antelope bitterbrush	*Purshia tridentata* (Pursh) DC.						X		X		X

protected from grazing had approximately four times the plant density and double the plant height.

On plots in 1947 the two lovegrasses maintained good stands while bush muhly and hooded windmillgrass had poor stands. Lehmann lovegrass, and plains bristlegrass of the row planting were surviving. By 1949 survival was mostly confined to mulch plots and the species of Lehmann lovegrass, Boer lovegrass, bush muhly, and hooded windmillgrass. Hooded windmillgrass and plains bristlegrass did not survive after 1954. The two lovegrasses and bush muhly survived until sometime between 1962 and 1965.

Cave Creek

Environment and Methods. — The Cave Creek site is about 50 miles north of Phoenix, (approximately 18 miles beyond Cave Creek at fork of Lookout Mountain and Cave Creek roads). It is covered principally with scrub liveoak *(Quercus turbinella* Greene) and broom snakeweed *(Gutierrezia sarothrae* (Pursh) Britt. and Rusby), with a scattering of Utah juniper *(Juniperus osteosperma* (Torr.) Little), prickly pear *(Opuntia* spp.), and curlymesquite *(Hilaria belangeri* (Steud.) Nash). The elevation is near 3,500 feet. Average annual precipitation is about 18 inches (Fig. 2). Removal of competing vegetation and rocky character of the soil were the limiting factors in successful reseeding of this site.

The area was so rocky that plots were first seeded and then harrowed. Harrowing destroyed from 5 to 10% of the broom snakeweed but damaged other shrubs little. The major plots in four replications were planted under fence. Strip plantings were 8 ft. x 1 chain. All the seedings here were completed in August.

Germination and Survival. — By 1949, under the juniper slash, there were good stands of Boer and Lehmann lovegrasses and white tridens. Since that time there have appeared, intermittently, plants of blue panicgrass, crested wheatgrass, and slendar grama. By 1965 the principal surviving species was Boer lovegrass with only scattered plants of sand dropseed, Lehmann lovegrass, white tridens and rough menodora.

Pine Creek

Environment.—This formerly cultivated, severely eroded site is approximately 10 miles north of Young. There were patches of sod of western wheatgrass, blue grama and sideoats grama. The approximate elevation is 5,100 feet. The annual precipitation is 21.53 inches (Fig. 2).

Methods. — Treatments were disking-broadcast seeding-mulching; disking-broadcast seeding-cultipacking; and broadcast seeding without seedbed preparation on abandoned farmed areas where there was little natural revegetation. The large plots were seeded in 8 replications on both protected and open range. Strip planting plots were ⅓ x 2 chains. All were planted in June.

Germination and Survival. — There was no emergence by the fall of 1945. By 1946 there were fair stands of Lehmann lovegrass, weeping lovegrass and crested wheatgrass, and a scattering of western wheatgrass and blue grama.

By 1947 only crested and western wheatgrasses had made good stands, both with and without mulching, on the plots prepared by disking. There was no evidence of response to the fertilizer. On the 1946 row plantings intermediate and pubescent wheatgrasses looked most promising with plants under the mulch more vigorous than those without. In 1950 the tridens began to appear on the mulched areas.

Gradually, all species except tridens, weeping lovegrass, and crested wheatgrass disappeared. By 1965 crested wheatgrass was the most abundant. There were a few plants of weeping lovegrass surviving. Those plots reseeded to western wheatgrass maintained a heavier stand than the nonplanted ones. All plantings made without seedbed preparation failed.

Buckhead Mesa

Environment. — Buckhead Mesa is about 5 miles southeast of Pine. The site had a rather heavy overstory of juniper and a thick ground cover of broom snakeweed. There was a remnant of sod composed principally of sideoats grama and blue grama. The elevation is approximately 5,000 feet. The average annual precipitation is 21.48 inches (Fig. 2).

Methods. — A method study was incorporated. One area included preplanting treatments of disking-broadcast seeding-cultipacking; disking-broadcast seeding-cultipacking-mulching with native brush; and broadcast fertilizing-disking-broadcast seeding. A second area was treated by juniper removal-disking-broadcast seeding-mulching; juniper removal-broadcast seeding; and no site preparation-broadcast seeding. Disking killed from 25 to 40% of the broom snakeweed.

Six replications of the major plots in the fenced area and one replication on the open range were planted in July. There were 7 replications of the strip plots planted. A 20-foot strip on these plots was mulched.

The 1946 plantings included 8 circular plots 20 ft in diameter where seed was broadcast and raked in. Competition was eliminated on half of the plots; half of each plot was mulched with brush. Three replications were resown by broadcasting and raking.

Germination and Survival. — In September 1945 crested wheatgrass and western wheatgrass were growing well. The species on the strip plots were flourishing, particularly under the slash (Fig. 3). Row plantings had emerged.

By 1947 the survival was confined primarily to mulch. Crested wheatgrass, western wheatgrass, weeping lovegrass, Turkestan bluestem, and little bluestem were outstanding. The status of row plantings was: intermediate and pubescent wheatgrasses, smooth brome, plains and sand lovegrasses, and wolftail, good stands; black and hairy gramas, smilograss and vine-mesquite, fair stands; tanglehead, poor stand.

By 1949 there was an excellent stand of Turkestan bluestem under the mulch and a good stand without litter. Under mulch the stand of weeping lovegrass was good to excellent; that of white tridens, good; and crested and western wheatgrasses, fair. For row plantings there were good stands of intermediate and pubescent wheatgrasses, plains and sand lovegrasses, with fair stands of crested wheatgrass and vine-mesquite.

By 1954, under mulch, Turkestan bluestem, weeping lovegrass, deergrass, crested and western wheatgrasses were of good to excellent stands. Only Turkestan bluestem was in good stand without mulch. On the circular plots good stands of crested and western wheatgrasses became established under mulching, both with and without cultivation. Thus, mulching may partially compensate for poor seedbed preparation.

In 1961 and 1965 the outstanding species were Turkestan bluestem, weeping lovegrass and western wheatgrass. Crested wheatgrass was disappearing. Turkestan bluestem was outstanding and was vigorously spreading.

FIG. 3. Persistence of slash after 20 years, Buckhead Mesa.

Summary and Conclusions

Longevity of range planting is important to public land administrators and ranchers who contemplate range restoration by this means. Experimental range plantings on the Tonto National Forest of central Arizona offer information in this respect. An analysis of plantings of 1945 and 1946 through 1965 provides information on longevity for four different environments. Annual precipitation and mean temperatures largely controlled species adaptability at the different sites.

At Black Hill (average annual precipitation 15.99 inches, average annual temperature 67.7 F) Lehmann and Boer lovegrass were the most promising of 25 species tried. At Cave Creek (estimated precipitation 18 inches, average temperature 58.7 F) Boer lovegrass (a cold hardy, drought-resistant species) was outstanding among the 30 species planted. At Pine Creek precipitation 21.53 inches, average temperature 57.8 F) crested wheatgrass and western wheatgrass (cool-season growers), of 23 species seeded, still survived in good stand after 20 years.

At Buckhead Mesa (precipitation 21.48 inches, temperature 52.8 F), of the 20 species seeded, Turkestan bluestem was outstanding without protective mulch and weeping lovegrass survived under a brush mulch.

Under the arid conditions and extensive seedbed preparation of these tests, protective brush mulch was highly important for stand establishment and maintenance.

Other factors may have had an influence on successful establishment of stands. Available moisture during seedling development, protection from grazing, elimination of competition, and adaptability of species no doubt played roles affecting the final results.

Public land managers and

ranchers should be able to effect successful range seeding by choosing species coordinated with the environmental conditions of this study.

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Protein, P, and K Composition of Coastal Bermudagrass and Crimson Clover

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Highlight

Increasing levels of N, P and K fertilization increased total nutrient uptake and the percentage of protein, P and K, in the Coastal bermudagrass forage. P and K content of associated crimson clover increased with increasing rates of application of each nutrient. Percent recovery of N and P in the forage declined with increasing rates of fertilization of each nutrient, but percent K recovery increased with increasing K rates. N-K balance was important in maintaining an optimum K level in the forage and reducing K-deficiency symptoms. Tame pastures supplement forest range and reduce the overall cost below that of tame pastures above.

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Coastal bermudagrass *(Cynodon dactylon* (L.) Pers.) was released as a variety 22 years ago and is grown on more than 6,000,000 acres in the United States (Johnson et al., 1964). The present acreage is small compared with the potentially adapted areas in this and other countries (Burton, 1965) .Forage production of Coastal grown on various soils and under a wide variety of fertilizer levels has been reported (Fisher and Caldwell, 1959; Prine and Burton, 1956).

The influence of K on the incidence of leafspot on Coastal bermudagrass has been reported by Evans et al., 1964. Pretty (1964) has shown the importance of K in animal nutrition and Teel (1964) has studied the role of K in converting N to true protein.

The purpose of this investigation was to determine the effect of different levels of fertilization on: (1) the protein, P and K contents of Coastal bermudagrass, (2) the P and K contents of crimson clover *(Trifolium incarnatum)* grown in association with the grass, and (3) total uptake and percent recovery of N, P and K. The forage yields have been reported in a previous paper (Adams and Stelly, 1962).

Procedure

This investigation was conducted during 1955-1957 on Cecil sandy loam soil. Cecil soil comprises more than half of the total upland soils of the Piedmont Province which extends from Maryland into Alabama. These soils are representative of the red-yellow Podzolic Great Soil Group and are derived from red to brown weathered granite and/or gneiss. Texture ranges from sandy loam to loam. The clay fraction of Cecil profiles contains more than 40% of koalinite, 10 to 40% vermiculite and less than 10% gibbsite. The cation exchange capacity is approximately 4.8 me/100 g, with a pH range from 5.2 to 5.7 (0-6") and a bulk density range from 1.43 to 1.22 g/cm^3 (0-6"). Percent moisture by volume is approximately 19.61 and 7.28 for the 1/3 bar and 15 bars, respectively.

The fertility requirements of Coastal bermudagrass grown with crimson clover were studied in a factorial experiment. The fertilizer treatments, replicated three times in a randomized block, were: 0, 100, 200 and 400 lb/acre N; 0, 22, 43 and 87 lb/acre P, (0, 50, 100 and 200 P_2O_5); and 0, 41, 83 and 165 lb/acre K (0, 50, 100 and 200 K_2O). The P and K were applied one-half in the fall at clover seeding and one-half in the spring after clover harvest. The N was applied 37.5% after clover harvest, 37.5% after the first grass harvest and 25% after the second harvest.

The plots were 8 by 20 ft in size and the harvested area was 34 inches by 18 ft. The entire harvested sample was oven dried and ground for chemical determinations.

Nitrogen was determined by the Kjeldahl method (A.O.A.C., 1945) and converted to protein by multiplying by the factor 6.25. Phosphorus and potassium were determined from plant samples ashed with perichloric, nitric and sulfuric acids. Phosphorus was determined colorimetrically by the molybdenum blue method with stannous chloride as the reducing agent. Potassium was determined by flame photometry according to the method of Wehunt et al. (1957).

All data were analyzed statistically. Duncan's Multiple Range Test was used to test for significant differences among treatment means (Duncan, 1951).

Results and Discussion

Coastal bermudagrass composition — Protein, P and K. — Nitrogen was the only nutrient applied that affected the protein content of the Coastal bermudagrass forage (Table 1). The protein content increased markedly from 9.44% at the O-N level to 16.37% at the 400-N level. The differences between all N levels were significant at the 1% level of probability.

Phosphorus fertilization significantly increased the P content of the Coastal bermudagrass forage (Table 1). The P content of the forage ranged from 0.17% at the 400-0-41 (N-P-K) level to 0.25% at the 400-87-0 level. The P level in this forage appears to be adequate for most livestock needs (Morrison, 1936).

The K content of the forage increased significantly with each increment of applied K and ranged from 0.74% at the 400-22-0 level to 1.84% at the 400-22-165 level (Table 1). At the three lower levels of K application, the K content of the forage decreased with increasing N levels. At the 165-lb level of K application, the K content of the forage increased with increasing N levels. The 200- and 400-N levels, the percentage K in the forage more than doubled as the K application was increased from 0 to 165 lb/acre.

Apparently, Coastal bermudagrass requires a high potassium content in the forage for optimum growth. Pronounced potassium deficiency symptoms—chlorotic leaves with dead edges—were observed on treatments receiving high N and low K applications, although forage samples from these treatments contained about 1% potassium.

P and K Content of Clover Forage.—The percent P in the crimson clover forage increased significantly with each increment of P applied to the Coastal bermudagrass (Table 2). The range was from 0.20% P at the 100-0-83 level of fertilization to 0.41% at the 0-87-0 level. The P content of the clover decreased slightly with increasing rates of both N and K.

The percent K in the clover forage ranged from 0.98 at the 0-K level to 3.00 at the 165-K level. There was a small, but

Table 1. Protein, phosphorus and potassium content of Coastal bermudagrass grown with Crimson clover at four levels each of nitrogen, phosphorus and potassium. 3-year average, 1955-1957.

N	P	Average Protein % at K Levels (Lb/A.)					Average P % at K Levels (Lb/A.)					Average K % at K Levels (Lb/A.)				
lb/A.	lb/A.	0	41	83	165	Avg.	0	41	83	165	Avg.	0	41	83	165	Avg.
0	0	9.87	9.75	9.81	9.44	9.71a	.20	.20	.18	.20	.20a	1.15	1.42	1.47	1.54	1.40a
	22	9.69	9.87	9.56	9.69	9.70a	.22	.22	.22	.21	.22b	1.16	1.35	1.56	1.62	1.42a
	43	9.56	9.81	9.37	9.75	9.62a	.23	.23	.24	.22	.23c	1.20	1.33	1.44	1.61	1.40a
	87	9.62	9.62	9.87	9.75	9.71a	.24	.25	.23	.23	.24d	1.23	1.49	1.54	1.59	1.46a
	Avg.	9.68a*	9.67a	9.65a	9.66a		.22a	.22a	.22a	.22a		1.19a*	1.40b	1.50bc	1.59c	
100	0	11.10	10.62	10.94	10.81	10.87a	.18	.19	.17	.17	.18a	1.00	1.28	1.57	1.61	1.37a
	22	11.00	10.81	10.75	10.44	10.75a	.22	.21	.20	.20	.21b	0.86	1.23	1.46	1.74	1.32a
	43	10.87	10.56	10.62	10.62	10.67a	.23	.22	.21	.22	.22c	0.93	1.24	1.49	1.71	1.34a
	87	10.56	10.81	10.94	10.56	10.72a	.23	.24	.23	.23	.23c	0.84	1.30	1.47	1.74	1.34a
	Avg.	10.88a	10.70a	10.81a	10.61a		.21a	.21a	.20b	.21a		0.91a	1.26b	1.50c	1.70d	
200	0	13.19	12.56	12.31	12.25	12.58a	.18	.17	.17	.17	.17a	0.88	1.16	1.55	1.80	1.35a
	22	13.37	12.31	12.44	12.31	12.61a	.22	.21	.21	.21	.21b	0.81	1.15	1.30	1.73	1.25a
	43	13.62	12.69	12.25	12.31	12.72a	.23	.23	.21	.21	.22c	0.86	1.20	1.33	1.84	1.31a
	87	13.06	12.37	12.12	12.12	12.42a	.23	.24	.23	.23	.23d	0.74	1.17	1.36	1.71	1.25a
	Avg.	13.31a	12.48a	12.28a	12.25a		.22a	.21a	.20b	.20b		0o82a	1.17b	1.39c	1.77d	
400	0	15.50	15.06	14.87	14.75	15.04a	.19	.17	.17	.18	.18a	0.87	1.14	1.53	1.90	1.36a
	22	15.81	15.56	15.12	15.31	14.45b	.23	.22	.20	.22	.22b	0.74	1.12	1.34	1.84	1.26a
	43	16.37	15.69	15.87	13.31	15.31c	.23	.23	.22	.22	.23c	0.84	1.06	1.78	1.80	1.25a
	87	15.56	15.31	15.37	15.44	15.42b	.25	.24	.24	.24	.24d	0.83	1.08	1.31	1.75	1.24a
	Avg.	15.81a	15.40b	15.31b	14.70c		.23a	.21b	.21b	.21b		0.82a	1.10b	1.37c	1.82d	

*Means in each group of four followed by the same letter are not significantly different at the 5 percent level of probability.

significant, reduction in the K content of the clover with increasing rates of both N and P. The K content of the clover generally declined at a constant K level with increasing N levels. This reduction reflected the increased uptake of K by the Coastal bermudagrass forage with increasing rates of N fertilization.

The percent K in the crimson clover forage declined at all fertilizer levels from 1955 to 1956 except where N was limiting all high K levels. At the 200- and 400-N levels, the decline in the percent K in the clover was as much as 25% from 1955 to 1956.

Nutrient Uptake and Recovery by Coastal bermudagrass and Crimson clover.—When the supply of other nutrients was adequate, Coastal bermudagrass made efficient recovery of applied N (Table 3). The efficiency of N recovery in the forage decreased as the N fertilization rate increased. Up to the 200-N level, Coastal bermudagrass recovered 86% of the applied N. Even at the 400-N level, 68% of the applied N was recovered in the Coastal forage during the year applied.

The excellent recovery of N by Coastal bermudagrass on Piedmont soils is similar to that reported on Coastal Plain soils (Burton et al., 1962) and indicates that this grass is efficient in N recovery under widely varying conditions.

The recovery of P in the

Table 2. Phosphorus and potassium content of Crimson clover grown on Coastal bermudagrass at four levels each of nitrogen, phosphorus and potassium. 3-year average, 1955-1957.

N Levels	P Levels	Avg. Phosphorus % at K Levels, lb/A.					Avg. Potassium % at K Levels, lb/A.				
lb/A.	lb/A.	0	41	83	165	Avg.	0	41	83	165	Avg.
0	0	.25	.22	.24	.24	.29a	1.31	1.93	2.48	3.00	2.18a
	22	.33	.30	.32	.33	.32b	1.31	1.69	2.45	3.00	2.11ab
	43	.38	.38	.39	.37	.38c	1.20	1.59	2.31	2.72	1.96 bc
	87	.41	.41	.39	.40	.40d	1.34	1.73	2.05	2.60	1.93 c
	Avg.	.34a*	.33b	.34a	.39c		1.29a*	1.74b	2.32c	2.83d	
100	0	.23	.22	.20	.22	.22a	1.11	1.73	2.36	2.79	2.00a
	22	.36	.31	.31	.28	.32b	1.11	1.51	2.00	2.82	2.00 b
	43	.38	.37	.36	.37	.37c	1.11	1.47	2.01	2.58	1.79 c
	87	.38	.41	.39	.38	.39d	1.22	1.44	1.90	2.58	1.79 c
	Avg.	.34a	.33b	.32c	.31c		1.14a	1.54b	2.07c	2.69d	
200	0	.27	.22	.22	.22	.23a	1.13	1.40	2.02	2.66	1.80a
	22	.36	.33	.29	.32	.33b	1.02	1.40	1.81	1.73	1.49 b
	43	.36	.35	.31	.32	.34c	.98	1.29	1.64	2.31	1.56 b
	87	.41	.39	.40	.39	40d	1.54	1.49	1.76	2.37	1.79a
	Avg.	.35a	.32b	.31c	.31c		1.17a	1.40b	1.81c	2.27d	
400	0	.29	.24	.26	.23	.26a	1.26	1.58	1.83	2.39	1.77a
	22	.30	.28	.32	.30	.30b	1.13	1.27	1.20	2.20	1.58 b
	43	.36	.37	.34	.34	.36c	1.18	1.31	1.61	2.17	1.57 b
	87	.39	.39	.37	.38	.38d	1.21	1.19	1.67	2.20	1.57 b
	Avg.	.33a	.32b	.33a	.31c		1.20a	1.34b	1.70c	2.24d	

*Means in each group of four followed by the same letter are not significantly different at the 5 percent level of probability.

Table 3. Nitrogen, phosphorus and potassium uptake and percent recovery by Coastal bermudagrass and crimson clover—1955-1957.

Nitrogen*			Phosphorus**					Potassium***				
Rate N	Uptake[1] N	Recovery	Rate P	Uptake, P Grass	Clover	Total	Recovery	Rate K	Uptake, K Grass	Clover	Total	Recovery
lb/A.	lb/A.	%	lb/A.	lb/A.	lb/A.	lb/A.	%	lb/A.	lb/A.	lb/A.	lb/A.	%
0	77.5		0	20.6	6.3	26.9		0	95.1	5.5	100.6	
100	163.9	86	22	27.2	9.7	36.9	45	41	135.2	14.7	149.9	120
200	248.7	86	43	29.8	10.7	40.5	32	83	184.2	24.9	209.1	131
400	348.1	68	87	34.5	15.0	49.5	26	165	259.5	61.4	320.9	133

*At 87-165 (P-K) **At 400-165 (N-K) ***At 400-87 (N-P)

[1] Clover not included.

Coastal and clover forage was considerably lower than the recovery of N (Table 3). The recovery of P at the 22, 43 and 87 lb/acre P levels was 45, 32 and 26%, respectively.

Coastal bermudagrass recovered the applied K more efficiently than any other nutrient (Table 3). The K absorbed from the soil by the Coastal and clover exceeded that applied at every level of K application. Even where 165/acre K were applied annually, at the 400-N level the K removal (grass and clover) was almost double that applied. The depletion of soil K at high forage production is in contrast to the accumulation of soil K at low N levels. The removal of K in the harvested forage at the lower N levels was not sufficient to seriously deplete the soil K.

The P and K uptake by crimson clover (Table 3) primarily reflects the influence of N, P and K levels on clover production. Both P and K uptake closely followed clover production when varying levels of each were applied. The P uptake by crimson clover was reduced by increasing nitrogen levels applied to the bermudagrass. This reduction in total P uptake was primarily due to a reduction in the yield of crimson clover. The P uptake by the clover increased with increasing levels of applied P (Table 3); P uptake at the 400-87-165 level was more than double that at the 400-0-165 level.

Increasing levels of N similarly affected K uptake by the crimson clover. The K uptake was reduced from 76.5 lb/acre at the 0-87-165 level to 61.4 lb. at the 400-87-165 level. Increasing levels of K increased K uptake by the clover and resulted in an elevenfold increase in K uptake from the 400-87-0 level to the 400-87-165 level (Table 3). This increase in K uptake was due primarily to the increased growth of the clover.

Supplementing Native Ranges.—Practically all southern ranges are seasonal and a combination of range and tame pasture must usually be worked out to achieve a practical year-round livestock operation. Improved pastures supplement forest range by providing: (1) hay in the spring and early summer for winter feeding, (2) fire-break strips through the forest and (3) furnish forage for livestock when they should be off the range. However, when native range is available to carry animals at least a part of the year, the overall cost of operation is generally reduced below that when cattle are carried on tame pastures throughout the year (Halls et al., 1964; Williams et al., 1955).

Summary

Increasing levels of N, P or K increased the percentage of protein, P or K, respectively, in the Coastal bermudagrass forage; also increased the total nutrient uptake of all three nutrients by Coastal bermudagrass. At the 400-N level of fertilization the P content of Coastal bermudagrass forage increased from 0.19% with no P fertilization to 0.25% when 87 lb. of P were applied. At the 400-N level the K content of Coastal forage increased from 0.83 to 1.15% as K fertilization was increased from 0 to 165 lb/acre. In general, much more P was applied than was recovered in the forage. High N fertilization resulted in the removal of almost two times as much K as was applied.

The P and K content of crimson clover increased with increasing rates of application of each nutrient at all N levels.

The percent recovery of N and P in forage declined with increasing rates of fertilization of each nutrient, whereas percent K recovery increased as K fertilization increased.

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TECHNICAL NOTES

Vegetative Apomixis in *Carex*

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Apomixis in its various forms has been reported for many plant species, but so far as can be determined this form of reproduction has not been previously reported in *Carex*. Apomixis has been observed in *C. ebenea* Rydb., *C. phaeocephala* Piper, and *C. egglestonii* Mack. grown under greenhouse conditions at Laramie, Wyoming. The development of apomixis in *C. ebenea* is described here.

The plant of *C. ebenea* originated as a volunteer seedling in soil brought to the greenhouse from the subalpine zone of the Snowy Range area west of Laramie. The plant germinated in April, 1965, and was saved for later identification.

The plant grew at the normally slow rate for sedges during the first few months. In September of 1965, however, it made very vigorous and lush growth. Greenhouse temperatures were controlled at about 70 F. Humidity varied, but during the daytime period averaged about 40%. Photoperiod was not controlled.

During this lush period of growth, seed stalks were produced and normal sexual flowering occurred (Fig. 1). At the same time, several leafy, semiprostrate culms developed. Small bulblike structures were formed at close intervals along these culms in the axils of the leaves. These structures put forth leaves and began to grow rapidly (Fig. 2). Leaves from these structures were

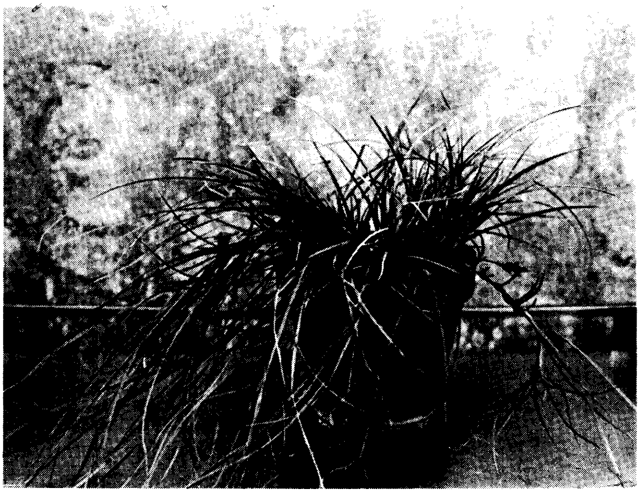

FIG. 1. The parent plant of *Carex ebenea* Rydb. Asexual reproduction is shown on the culm to the right of the plant, along with one of the normal seed heads from the same plant.

FIG. 2. Close-up of leafy culm bearing asexual bulbils. Various stages of development are shown. Some of the leaves have been clipped for better illustration.

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[1] *Forest Service, U. S. Department of Agriculture, with headquarters at Fort Collins, in cooperation with Colorado State University. Research reported here was conducted at Laramie, in cooperation with University of Wyoming.*

somewhat thicker, darker green, and more lustrous than those of the parent plant. They were easily detached, and if placed in water immediately sprouted roots (Fig. 3). Some of them were rooted in water, placed in soil, and developed into new plants. Both the root and shoot dvelopment from these structures was much more rapid than the growth from seedlings.

Terminology for this type of asexual reproduction is not clear. Apomixis is used to designate asexual reproduction, but the term is very general. Hayes et al. (1955) separate apomixis into vegetative apomixis (types of reproduction that substitute for the sexual method) and agamospermy (asexual reproduction through seed production). Under the general heading of vegetative apomixis, bulbils are listed as a method of reproduction. Northen (1958) defines these as small, bulblike structures formed in the axils of the leaves (or at times in the flower) which serve to propagate the plant. This definition seems to describe most accurately the type of asexual reproduction observed on *C. ebenea*.

FIG. 3. Close-up of detached bulbil showing beginning of root system that develops when moisture is available.

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Marking Cows with Human Hair Dye

PAT O. CURRIE

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Highlight

Large, easily applied numbers could be read at considerable distance for the life of the hair coat—150 to 180 days when applied in the fall.

The usual methods of marking cattle—ear tags or neck chains—are often unsatisfactory in livestock management and research. When obtaining birthweights of calves at the Manitou Experimental Forest in Colorado, for instance, it was nearly impossible for us to get close enough to range cows to read ear tags. We needed a large identifying number that could be applied to the cows prior to calving, and that would last several months.

In an attempt to find a suitable dye that was readily available, easily mixed, and could be applied over a wide range of temperatures, Miss Clairol,[2] a typical woman's hair dye, was used to mark the cows. This dye fulfilled these criteria and is readily available at any drugstore or cosmetic counter in a wide range of colors. Other brands would be expected to perform similarly.

Initially a black dye was used to put identifying numbers on the cows in January. The numbers remained visible until after the calves were born in March and April, and were easily readable for a considerable distance (Fig. 1). No adverse effects on animal hair or skin could be detected, and the dye remained effective through the life of the hair coat.

To better evaluate lasting qualities, the dye was then applied and observed throughout different seasons of the year. As shown below, life of the dye marking is shortest

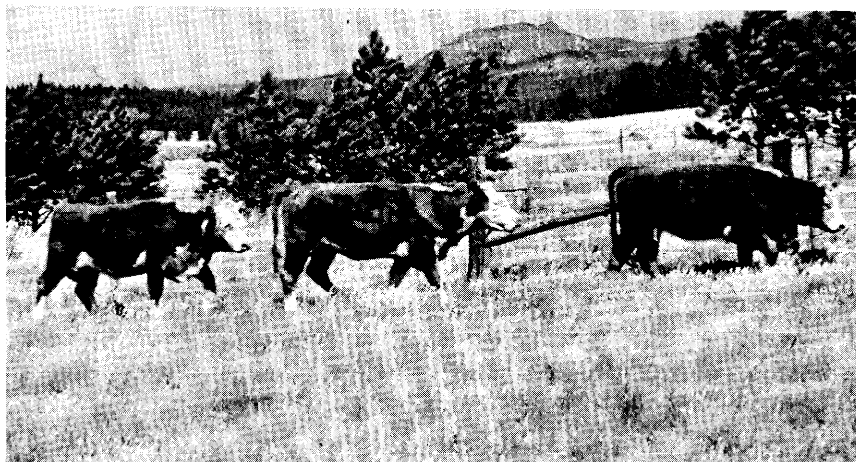

FIG. 1. Dye markings applied as large block numbers were readily readable at a considerable distance.

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[1] *Forest Service, U. S. Department of Agriculture with headquarters at Fort Collins in cooperation with Colorado State University.*

[2] *Mention of a trade name or product is for the convenience of the reader, and does not constitute endorsement or preferential treatment by the U. S. Department of Agriculture.*

in the spring or fall when the hair coat is either being shed or coming in:

Date Applied	Days Readable
Sept. 1	60
Oct. 15	150-180
May 19	60

When applied after October 15, numbers remained legible for 5 to 6 months, even on dark red animals, but lasted only 2 months in the spring or fall. Comparable lasting qualities with the dye were obtained on experimental animals at the Central Plains Experimental Range by R. E. Bement of the Agricultural Research Service. He applied the dye in May, and had to make a second application in August. This last application was readable until the end of September, but then faded as the new hair growth came in with cool fall weather.

In addition to the black dye, a red dye was used on the white faces of Hereford animals. It also worked well, but the advantages gained were not worth the time consumed in applying face markings.

When first applied, the dye may appear wet or perhaps a dirty brown. Since about 15 to 30 minutes are required for the color to develop, the dye should be applied thoroughly just once, then allowed time to color. Protective gloves and old clothing should be worn, although the material is not particularly harmful to the skin.

At Manitou, two shoe-polish bottles equipped with daubers were used to mix the dye and apply the numbers to the cows. Half the dye was put in each shoe-polish bottle, and an equal amount of hydrogen peroxide added. The two bottles marked 24 animals with large numbers at a total cost of less than $1.50. Mr. Bement used a vegetable brush to mark the experimental animals at Central Plains Experimental Range at a comparable low cost.

Either of these two methods works well for marking only a few animals, and the entire contents of a bottle need not be used at one time. The remainder of the dye and peroxide can be saved for future use within the restriction stated on the bottle for storing conditions and longevity. If a large number of animals are to be marked, a more efficient method, such as a pressure spray can, may be feasible. (Note: Hair color is applied in Beauty Salons in plastic squeeze bottles. This method might work on cow hair.—Ed.)

Human hair dye for marking cattle should be useful wherever an identification mark may be needed for a relatively short time. For example, in artificial insemination work individual cows could be marked with a suitable code number to denote the difference in herd sires or breeding date. Also in beef herd improvement programs where pregnancy testing is common, cull animals could be marked when they are tested. If the operator did not wish to sell or separate cull animals at this time, he could easily separate and gather the marked animals from the herd at a later date, and thereby avoid considerable handling.

MANAGEMENT NOTES

Cooperative Range Management in Oregon—Sagebrush Control

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Highlight

Sagebrush control on suitable sites continues to be a desirable range improvement practice. In Oregon, rancher-Extension cooperative planning groups allow pooling of individual acreages resulting in extremely low bids for both herbicides and aerial application. Brush control and range seedings provide needed flexibility in range management planning.

Sagebrush control, where sufficient desirable understory grasses are present, continues to be an excellent tool of range management. It has been found generally from the sand-sage areas of the plains to the big-sage in the West that "on the right site" money spent for sagebrush control is a sound investment.

In many areas brush control and other range improvement programs of land managing agencies have far overshadowed programs on private land. This is not so in Harney County, Oregon. The need for and value of sagebrush control programs has been well recognized by ranchers in Harney County. For the past 14 years, County Extension Agent Ray Novotny and rancher committees have organized sagebrush control programs on a county-wide basis. Harney County, with 6,483,840 acres is located in southcentral Oregon. Over 73% of the county is in public ownership. Of the remaining

1,530,000 acres in private ownership, approximately 1,343,000 are rangelands. An estimated 25% of the private land or 335,700 acres could be seeded. Over 35% or 470,000 could be sprayed for sagebrush control. Forty percent or 579,000 acres could be improved by management alone. A Bureau of Land Management district and parts of two national forests lie within county boundaries. Both land managing agencies have had range improvement programs underway for some time. As in most cases, Federal range programs are not intended to or cannot accomplish the total improvement program. Development on private lands is also essential. In some cases, such as Harney County, they lead the way.

To begin with, but also concurrent with control programs, Agent Novotny developed educational programs to provide information on the value of sagebrush control, range seeding, and other improvement and management practices. This included the selection of sites, forage increases to be expected, influence on livestock performance, and other management implications. The educational program was helped along significantly by the presence and work of the researchers at the Squaw Butte Experiment Station located in Harney County.

During each winter, the county agent and a small planning group of ranchers develop plans and procedures for the spring sagebrush control program. This requires a survey of interested ranchers to determine location and number of acres to be sprayed. Once the information is assembled, separate bids are let for the spray material (2,4-D butyl ester) and aerial application. Aerial application bids are divided into fixed-wing and helicopters. Both types of aircraft are utilized where necessary to do the best job of brush control under a variety of conditions. The benefits of group action for brush control can be demonstrated by the bid prices obtained for 1966. The bid to furnish 6,000 gallons of 2,4-D butyl ester (6 lb/acre acid equivalent) delivered in Burns was just under 60¢ lb. Bids to cover aerial application (including flagging) were around 80¢/acre for fixed-wing and $1.40 for helicopter. Thus, total costs of applying 2 lb herbicide are about $2.00/acre with fixed-wing aircraft and $2.60 for helicopter. For the most part, herbicides have been applied in 5 gallons of water with a sticker spreader, but some diesel has been used. This certainly is a very good price when compared to the $2.00 to $3.50 application costs alone reported in some parts of the West in the past year or so.

Wildlife habitat is not ignored even though the brush control programs are conducted on private land. In the high country, aspen and willow thickets are skipped. Other desirable browse plants such as bitterbrush are carefully avoided. In addition, sagebrush is not sprayed on rough, steep canyons that are especially desirable for wildlife.

As a result of this program which has developed over the past few years, significant accomplishments have been made in Harney County (Table 1).

Range revegetation, consisting primarily of seeding crested wheatgrass, has been a major program in Harney County along with the brush control. Seedings of crested wheatgrass provide early spring forage, and allow deferment of sprayed and other native ranges. A combination of seeded, sprayed, and non-treated native ranges provides great flexibility in management programs on both public and private lands.

Table 1. Acres sprayed and seeded by private ranchers and public land managing agencies through calendar year 1965 in Harney County, Oregon.

Ownership	Sprayed	Seeded
Private	74,200	38,000
BLM	44,335	111,000
Forest Service	7,424	8,637

Exactly what this means to Harney County is hard to say. An estimate of the value of such a program if continued was recently made by Art Sawyer, Superintendent of the Squaw Butte Station. He estimated that if range improvement potentials in the county were fully developed by 1975, Harney County could run 25% more cows, calf weaning weights could be increased by 50 lb., and the calf crop increased 10%.

The combining of these factors would result in an increase of salable calf weights from 15½ million to 23½ million lb. annually, or an increase of 51%. Figuring a 20¢/lb. calf, that would amount to an annual income increase to the ranchers of $1,600,000.

Sawyer goes on to explain that such accomplishments can only be realized by maintaining a balanced year-around forage supply, improving nutrition, management, and quality of livestock, and planning ahead for the long haul.

This program serves to demonstrate what can be accomplished in range management when a group of private ranchers see an opportunity and decide to take advantage of it. The county extension agent served as a catalyst, an organizer, and as a source of information around which the program was built. All lands, public and private alike, have and will continue to benefit as a result of this program. The economy of the county has been and will continue to be strengthened as a result of this program of cooperative range management.

BOOK REVIEWS

The Management of Land and Related Water Resources in Oregon. By Charles McKinley. *Resources for the Future, Inc., Washington, D.C., 522 p. 1965. Supplement (index), 19 p. 1966. (Limited publication primarily for libraries — not for sale.)*

This limited edition book contains the results of a monumental research project undertaken as a "case study in administrative federalism." The work, made possible by grants from Resources for the Future, Inc., and the Social Science Research Council, was carried out over seven years. The focus was upon the "complex federalistic administrative structure" that has grown up for the attainment of land, forest, and water management.

Members of the American Society of Range Management will be especially interested in Dr. McKinley's observations of "inter-level and group relationships" involved in efforts to attain effective range management on national forests and grazing districts in Eastern Oregon. Detailed accounts are given of range use controversies with which many Oregonians are familiar. One chapter is devoted to the Sisley Creek Allotment Case as it progressed from 1950 through 1963, naming names, giving dates, and concluding, among other things, that grazing management of the public domain is still loaded down with compromises made by the late Secretary Ickes at or about the time the Taylor Grazing Act was enacted.

Dr. McKinley pulls no punches, quoting freely from official documents, including advisory board minutes, appellate brief, and letters from Members of Congress. Knowledge of the background of a case such as Sisley Creek provides invaluable perspective to all who must deal with similar situations that may arise from time to time.

Dr. McKinley criticizes the operations of the district advisory board involved in the Sisley Creek case as having a "net-negative value . . . as an aid to the administration of the public domain lands." The grazing advisory board system generally as he observed it in Oregon was characterized as a "perversion of the advisory concept." He accepts the universal practice of using informal arrangements to gain cooperation in public administration and feels that intensive study of experience with the advisory mechanisms is needed to avoid overdependence on intuition and imagination.

The author's pessimistic view of stockman-Bureau relationships under present systems of managing the Federal Range may not reflect experience in other localities and regions. It has probably omitted from consideration the healing effects of forage expansion through well-financed large-scale range rehabilitation programs. One evidence of the latter is the fact that ranchers in the Cow Creek and Westfall units have recently withdrawn their appeals from grazing reductions dating back to 1959. The withdrawals followed the district manager's announcement that the earlier forage deficits have been largely overcome as a result of the "Vale Project," initiated in 1962.

Dr. McKinley's conclusions parallel professional range management thinking in many respects. For instance, he commends the trend toward professionalism in district range management, cautioning that appellate "lawyer judges" must not distort technical requirements and agency heads, and departmental superiors must not "buckle" when "political activity" intervenes. Some of the district managers, he concluded, "have shown great endurance of social disapproval in order to do their public and professional duty and keep faith with their own consciences." "But man is a social animal," he added, "and there are limits to his ability to accept the role of an S.O.B., even though conscience and some of his superior officers tell him it is not so."

Other chapters concern forest land management, soil conservation on private farms, recreation management, and fish and wildlife management on lands in Oregon.

The volume is valuable for its wealth of facts and citations as well as for the author's judgments. It is recommended reading for participants in the continuing dialogue between citizens and government in conserving and developing natural resources in Oregon and other states. —*Karl S. Landstrom,* Department of the Interior, Washington, D. C.

NEW PUBLICATIONS

PLANT BIOCHEMISTRY. — *(From the advertisement leaflet.)* "Edited by two of the most outstanding men in the field, PLANT BIOCHEMISTRY is the only definitive work on the biochemical activities of plants. Individual chapters are written by selected authors—specialists in their particular fields. The various topics are covered comprehensively, beginning with the presentation of general principles and ending with the current status and most recent research in the area." Edited by James Bonner and J. E. Varner. Academic Press, 111 Fifth Avenue, New York, N. Y. 10003, January 1966. $19.00. 1055 p.

Range Management Theses 1961-1965

COMPILED AND EDITED BY THADIS W. BOX
Texas Technological College, Lubbock.

Research by graduate schools in Range Management represents a large portion of the current work in the range field. Unfortunately, this material is not widely distributed and is sometimes slow in finding its way into print. Kinsinger and Eckert (1961, 1962) published titles of theses and dissertations from the range schools from 1955-1961. Since that time, there has been no published annual list. The Range Management Education Council voted in February, 1966 to compile the thesis titles annually. This list represents theses completed in the years 1962-1965. Theses titled for 1966 will be published next year.

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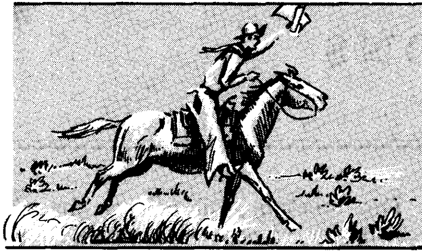


NEWS AND NOTES

Material from many sources; not necessarily the opinion or position of the EDITOR or OFFICERS of THE AMERICAN SOCIETY OF RANGE MANAGEMENT

Bureau of Land Management Marks Twentieth Anniversary

Twenty years ago, on July 16, 1946, three federal agencies were combined to form the Bureau of Land Management in the U.S. Dept. of the Interior. Dramatic contrasts can be drawn between current resource management and earlier levels of operation, according to BLM. Agencies combined were the General Land Office (in operation since 1812), the Grazing Service (established following the Taylor Grazing Act of 1934), and the O&C Administration (established by the O&C Act of 1937). Nationwide, BLM administers 464 million acres—nearly twice as much land as that under the jurisdiction of all other federal agencies.

The Meat Animal Research Center, a new U.S.D.A. unit near Clay Center, Nebr., is being staffed and stocked.

Plans for the 35,000-acre Center were announced last November by Secretary of Agriculture Orville L. Freeman. The center, part of USDA's Agricultural Research Service, will acquire 5,000 beef cattle, 10,000 sheep, and 3,500 hogs—all during the next 3 or 4 years. Eventually, about 65 scientists and supporting personnel will conduct basic and applied research in many phases of livestock and meat production. Dr. Keith E. Gregory, recently appointed director of the Center, was to transfer there in July. He was Investigations Leader of the ARS North Central Regional Beef Cattle Breeding Project with headquarters in Lincoln, Nebr. Appointed to serve as assistant director for operations is Walter

W. Rowden, a beef cattle researcher at Lincoln.

R. Dean Humphrey, previously superintendent of the ARS Southwestern Range and Sheep Breeding Laboratory, Fort Wingate, New Mex., and research technician Charles Manning of Fort Wingate have also transferred to the Center.

The first 50 beef cows and 950 sheep are already at the Center. The cattle came from the ARS Fort Robinson Beef Cattle Research Center, Crawford, Nebr., and the sheep from the Fort Wingate Station.

Utah State University to do basic research on herbicides under a $69,591 grant awarded by U.S.D.A. Information developed in this study should be helpful in improving weed control methods.

Sponsored by USDA's Agricultural Research Service, the 4-year study will be directed by Dr. J. LaMar Anderson, plant physiologist of the University's Plant Science Department. ARS technical representative is Dr. Dayton L. Klingman. The basic studies will provide additional information on the structural modification of plants by herbicides. Specifically, the scientists will determine the modification of plant organs, tissues, cells, and subcellular particles. Both resistant and susceptible crop and weed plants will be used in examining the effects of each herbicide.

Colorado State University Personnel Changes—Several personnel changes have been made within the University's College of Forestry and Natural Resources effective July 1 according to Dean C. H. Wasser. Dr. Robert E. Dils, formerly Leader of the Cooperative Watershed Management Unit becomes Associate Dean (Research). Dr. Jon J. Norris is the new Head of the Range Science Department replacing Dr. Donald Hervey, now Associate Director of the Colorado Agricultural Experiment Station. Dr. Gustav Swanson, presently Head of the Conservation Department at Cornell University will become Head of the Department of Fishery and Wildlife Biology effective October 1. Dr. Swanson replaces Professor J. V. K. Wagar, retired. Dr. A. T. Wilcox, Professor of Outdoor Recreation has been named Head of a new Department of Recreation and Watershed Resources.

New faculty members in the College include Dr. George M. Van Dyne, Dr. Charles Mahoney and Dr. William D. Striffler. Dr. Van Dyne, Associate Professor of Biology will work in the area of Systems Ecology and Range Nutrition. He has been Associate Professor of Biology, University of Tennessee and Health Physicist (Ecologist), Oak Ridge National Laboratory, AEC. Dr. Mahoney joins the staff in the Department of Recreation and Watershed Resources as Associate Professor of Outdoor Recreation. He was formerly with the Biology Department, Genesee State College, New York. Dr. Striffler will become Assistant Professor of Watershed Management in the Department of Recreation and Watershed Resources. He is currently project leader of the Strip-mined Area Restoration Project for the U. S. Forest Service at Berea, Kentucky.

Richard S. Aro has joined Elanco Products Company, a division of Eli Lilly and Company, as a plant science representative. He will provide field technical service for Elanco's agricultural chemicals in the state of Iowa. Aro attended schools in Rockville Centre, New York. He received a BS in agriculture from Montana State College in 1957, and a year later, was awarded the MS in range management from the University of Wyoming. Prior to joining Elanco, Aro was associated with the United States Geological Survey, Denver, Colorado. Aro is a member of Sigma Xi, honorary scientific fraternity, and ASRM. He and his family will reside in Iowa City, Iowa.

WITH THE SECTIONS

CALIFORNIA

The Section held its annual spring tour at Yreka on May 26 and 27. Program chairman Harry Taylor, USFS, ably assisted by Dave West, Farm Advisor, and Paul Friedrichsen, USFS, had arranged a very interesting and informative tour. An SCS plant testing station and range seedings on ranches and on BLM and Forest Service lands in Siskiyou County were visited. The snow-covered slopes of Mt. Shasta furnished a scenic background for the stands of wheatgrasses and alfalfa. About 60 persons heard ranchers and SCS, BLM, Forest Service, Extension Service and Calif. Fish & Game representatives discuss local livestock and game range problems. A demonstration of an electronic herbage meter by Don Neal and his father caught the eye of those faced with the perennial task of clipping plots. An evening banquet featured Don Hedrick, Oregon State Univ. and Sedg Nelson, Siskiyou Co. Farm Director, as speakers.

President "Coop" Cooper's appeal for support was heard with receptive ears as eight new members were signed up during the course of the tour. President-elect Eamor Nord announced that plans for the fall meeting at San Diego on November 17 and 18 were nearly completed. This meeting will feature the presentation of papers on technical and general interest topics.

NEVADA

A steak barbecue Tuesday evening, June 21, at the Fair restaurant in Cedarville, California highlighted the annual Spring Tour of the Nevada Section. E. R. Jackman and Reuben Long, authors of the popular book "The Oregon Desert," along with John Scharff provided after-dinner entertainment for the 150 local people and tour guests from Nevada, Northeastern California, and South Central Oregon.

The Tuesday afternoon tour in-

Wheatgrasses and alfalfa produce dryland hay crop on the G & H Ranch in western Siskiyou County, Calif. Such seedings are key to successful ranch operations in this area.

Bob Rodriques of the Bare Ranch explaining his setup to Nevada Section members. A gravity sprinkler system diverts water from Bare Creek through a 24-inch pipeline to irrigate 500 acres of alfalfa hay—yields average 5 tons/acre.

cluded stops at the Fee Ranch in Fort Bidwell and BLM range improvement work in the Boggs area east of Lake City. The group saw alfalfa production on the Hussa Ranch Wednesday before leaving Cedarville for Owl Creek where improvements for flood control and water conservation were explained. The tour continued to the Bare Ranch to look at conservation developments, including a major gravity irrigation system before going up to Patterson Guard Station in the Modoc National Forest where lunch was served.

Don Coops spoke on "The Place of Soil Conservation Districts in Resource Development and Management." Forest Service improvements viewed by the group included water spreading work at Patterson Meadow and a proposed dam at Bear Camp. Don Neal from the Pacific Southwest Forest and Range Experiment Station at Berkeley explained an electronic herbage measuring device. Lawrence Fee entertained the group throughout the tour with history and interesting stories of Surprise Valley.

Hosts for the tour were the Vya and Surprise Valley Soil Conservation Districts. The Modoc cattlemen assisted at the barbecue. The Modoc Chamber of Commerce and various resource agency people also helped make the tour a success. Tour chairman was James Linebaugh, Cedarville.—*Elmer L. Davis, Winnemucca.*

NEW MEXICO

Spring Section meeting was held June 3 and 4 at Farmington. Program Chairman Jody Boston and Arrangements Co-chairmen Jack Haslem and Alan Knight arranged a very informative session which included a tour of the Middle Mesa portion of the Navajo Dam Land and Wildlife Management Area. Evening banquet featured Utah Construction Co., Morgan Lake Mine, and Arizona Public Services Power Plant. Second day tour included the Manzanares Mesa Range improvement and management area and the Navajo Indian Irrigation Project tunnels at Gobernado Wash.

NORTHERN GREAT PLAINS

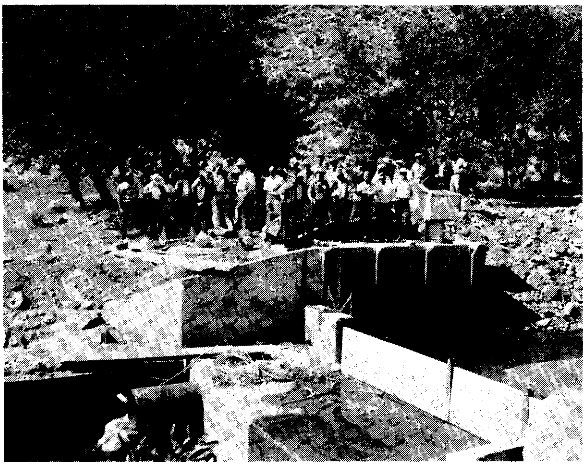
New officers of the Montana State University Range Club for 1966-67 are: Scott Hoag, President; Gene Langhus, Vice President; Bill Miller, Secretary; and Douglas Campbell, Treasurer. Some of our activities this spring include cooking the meat for a barbecue held in conjunction with the Little International Livestock Show. Also we entered a judging team in the judging contest held the night before the Little "I". This contest consisted of the following divisions; Animal science, Chaff and Dust, and Range Management (which was set up by the Range Club). We topped all the teams on campus to win the sweepstakes in this contest.

Our pet project was sponsoring a field day for the local 4H clubs. Nine 4Hers and 4 adults attended. The program consisted of instruction in plant identification and pressing and the demonstration of two kinds of range analysis. These were the Parker 3-step and plot clipping methods. Members of Range Club were quite impressed with the enthusiasm and ability of the 4Hers to learn and we came away with the feeling that we had really accomplished something. — *Gene Langhus,* Secretary, MSU Range Club.

PACIFIC NORTHWEST

Over 100 technicians and ranchers came to Vale, Oregon on June 1-2 to see how BLM makes better grass in the high desert. The timing was dramatic. This was the year for the rainclouds to get lost, not even enough moisture for the cheatgrass to grow. The BLM seedings and rehabilitated areas were about the only green spots in the county other than the irrigated areas. This showed the value of the deep root systems of the perennial grasses. The surprise package was the way the native perennial grasses came back under good management.

The natural resource conservation program in the Vale district has been underway for four years. Over 153,000 acres have been reseeded. The goal is 428,000 acres. Brush control for grass release is complete on nearly a third of the 715,500 acres to be treated. Nearly half the 2100 miles of fencing is done. Other re-



Nevada Section tour members at Owl Creek Irrigation Project—includes a large diversion dam, pipeline, and concrete ditch which conveys water to 5700 acres of irrigated land owned by six ranchers.

Two MSU Range majors (left) show 4H members how to identify Idaho fescue.

Pacific Northwest Section tour in Malheur County, Oregon, June 1-2. Max Lieurance, BLM District Manager, shows group location of six watering troughs fed by 4.5 miles of pipeline from a 540-ft well and 18,000 gallon storage tank.

Officers and Committee Chairmen. Pacific Northwest Section at summer meeting, May 31, 1966, Vale, Oregon. L. to R., front row: Grant Harris, Andy Wright, Howard DeLano, John Clouston, Dillard Gates, Robert Harris; second row: Claude Dillon, Charles Rouse, Charles Waldron, Brian Radford, Al Oard; third row: Graham Rice, Joe Mohan, Fremont Merewether.

habilitation measures include road construction, fire guard stations and lookouts, fire breaks, and wildlife habitat improvement. The range rehabilitation is benefitting nearly all the BLM land in the district, nearly 5 million acres. Reseeding part of the area permits deferred grazing on the balance and opportunity for plants to restore their depleted vigor and to reproduce.

The second day's tour covered some of Malheur County's intensive agriculture practices. The Malheur County Experiment Station was visited, where the value of deep plowing, seed selection, etc., was demonstrated. Outstanding examples of the management of private irrigated pastures were viewed.

Social highlights included a dinner at the Golden Slipper, at which section president Howard DeLano, was presented a gift (a Malheur County product), for a job well done. A buckaroo breakfast the next morning put people back on their feet for another day's field tour.

Max Lieurance and his committee earned a vote of congratulations for sponsoring a fine meeting.—*Fremont W. Merewether,* Secretary.

The Palouse Chapter started off the 1965-66 W.S.U. school year with the usual gathering after summer vacation. The meeting was held at the home of our advisor, Dr. Grant A. Harris, to get things planned for the coming school year, to introduce new students majoring in range management, and to give the members an opportunity to show slides of their summer's work. In addition to our regular meetings we also kept up the tradition of joint meetings with the North Idaho Chapter at the University of Idaho located only eight miles east from our campus.

The first joint meeting was highlighted by John Schwendiman of the SCS Plant Materials Center, who spoke on range reseeding in the West, with slides.

The next two meetings were at the U. of I. At the first meeting, Harry Vogt, SCS Area Conservationist from Moscow, Idaho, spoke on the advantages and disadvantages of different species of wheatgrass on the range. The second meeting featured Dr. Richard Dingle, WSU Department of Forestry, Claude Dillon, SCS Range Conservationist for Washington, and Scoop March, Chief of the BLM Division of Resource Program Management in Idaho, all speaking on Professionalism in range and forestry. The last joint meeting was an open house in honor of Dr. L. A. Stoddart, at the home of Dr. Harris. Dr. Stoddart was on campus to review the range research program of the department.

To add some spice to life this year, the range management chapter held a dinner dance at the home of Dr. Harris. Even though final exams were imminent, the members joined in to make a very successful party.

The Forestry and Range Management Department at Washington State University was accredited by the Society of American Foresters this year. The Department was also honored by the establishment of a new scholastic honorary fraternity, Xi Sigma Pi.

The appointment of Dr. Ben Roché as associate professor of range management will materially strengthen the range management program. His time will be split three-fourths to teaching and one-fourth to range extension. Boyd G. Hill, a range graduate of WSU and past president of the chapter, was appointed manager of the 12,000-acre Colockum Research Center.

The Range Club accepted a project at the request of Dr. Dillard Gates, President of the Pacific Northwest Section, to compose a slide story of the vegetation types of the Pacific Northwest. This project was put under the guidance of Dr. Roché and two members of the Club.

The officers for the past year were Karl Kipping, president; John Flerchinger, vice-president; Chuck Perry, secretary-treasurer; Steve Fuhrman, A.S.C.A. representative; and Larry Levien, reporter. Next year's officers are John Flerchinger, president; Steve Fuhrman, vice-president, Sheila Sampson, secretary; Rick Andersen, A.S.C.A. representative; and Norman Green, reporter.

SOUTH DAKOTA

More than 50 people from as far as 300 miles came to visit John Glaus Ranch tour June 17, near Chamberlain. John and his boys specialize in producing better cattle with better grasses and feeds. John has over 2,000 acres of good quality rangeland near the Missouri River. He uses both winter and summer ranges for 300 cows. He has some terraced pasture in high range condition; he has rejuvenated old crested wheatgrass areas and interseeded legumes. John's visitors drank 10 gallons of coffee and lemonade.

SOUTHERN

Section Annual Meeting will be held September 7 and 8 in Alexandria, Louisiana. Tentative program includes a technical session, banquet, and field tours. Theme is "What is New in Range Management".

TEXAS

Section field day was held on George Skeete's ranch June 24. Gerry Thomas of Texas Tech was MC for the morning session, which featured Howard Passey of SCS, and Don Huss and Chuck Leinwebber of Texas A&M. The ranch is northeast of Water Valley. The West Texas Assoc. of SWCD had their meeting on the same day and took in the ranch tour. See George Skeete's article about his ranch operation in this issue of the Journal.

Texas Tech Chapter held its final meeting for the school year on May 7, at Buffalo Springs Lake, Lubbock. New officers were installed (see photo). The afternoon centered around beef barbecue, volleyball, and horseshoes. About 35 student members were present with their wives and dates. Thadis Box, J. L. Schuster, and John Hunter, Professors of Range Management, served as cooks. Old officers were: Darrell Ueckert, President; Jimmy Brown, Vice-president; Gerald Horn preceded Jack McClung as Secretary-Treasurer; and Virgil Helm and George Mitchell on the Executive Council. Lynn Gibson preceded George Mitchell as Agriculture Council Representative.

Newly elected officers are George W. Mitchell, President; Gene Campbell, Vice-president; Roger Banner, Secretary-Treasurer; and Don Smith and Joel Dennis on the Executive Council. Jack McClung is Agriculture Council Representative.

The first meeting of the past school year was held September 22, 1965. Plans were made for the Ranch Management Conference sponsored by the Section and the Texas Tech Chapter held on the Texas Tech campus in October. The Tech Chapter presented certificates of merit for outstanding contributions to range management to Mr. Edwin Forrest and Tom Copeland.

Texas Tech Chapter meeting, May 7, 1966. Newly elected President for 1966-67 George Mitchell taking over from Past-President Darrell Ueckert.

Monthly meetings were held throughout the year. Dean Gerald Thomas presented an interesting program on the potential range resources of Angola, Africa. Charles E. Fisher, Superintendent of the Texas Agriculture Experiment Station at Lubbock, presented an informative program on brush control. Messrs. Jack Douglas and Don Allison, representatives from the New Mexico SCS spoke on opportunities for future graduates in Range Management. David Stephens, Superintendent of Panhandle National Grasslands, was the last guest speaker and spoke on employment opportunities in the U. S. Forest Service.

The Texas Tech Range Plant Identification Team won first place in the ASRM Annual Meeting contest at New Orleans in February, 1966. Jimmy Brown was high individual. Other members of the team were Darrell Ueckert, Jack Prichard, and George Mitchell; coach is Dr. J. L. Schuster.

UTAH

The Section made final arrangements for Annual Summer Meeting of ASRM at Logan July 27 to 30. Program included technical session and two days of tours. Congratulations from the parent ASRM Society to the Utah Section for all-out effort. Section Annual Meeting will be in Salt Lake City December 10.

WYOMING

The Section sponsored two young people to attend the First Range Youth Fact Forum at the Annual ASRM Summer Meeting in Logan, Utah. Delegates were selected by means of a Statewide essay contest.

Section Summer tour was planned for the Pinedale area on August 13.

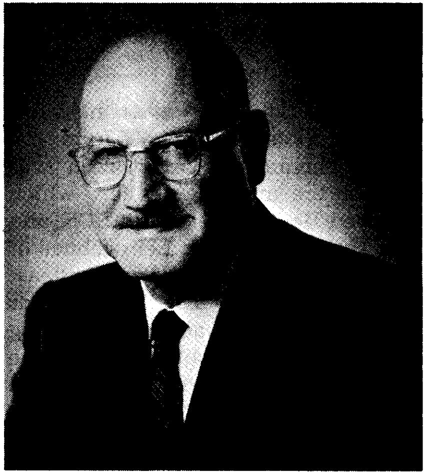
SOCIETY BUSINESS

Is Range Management a Worthwhile Profession?

MELVIN S. MORRIS
President, American Society of Range Management, Missoula, Montana.

It is not uncommon for an individual to take stock of himself; to attempt to assess his efforts in terms of his abilities, achievement on the job, and finally the satisfaction with what has been done. In some activities, as in salaried employment or in business, this can sometimes be measured readily by income. In some professions where service to the public is largely involved, the dollar return is at best a limited one.

To many of us assessment occurs at various times and places. It may come after contact with another individual. It may follow an evaluation of a project. It may come during or after a day in the field. It may be the consequence of meeting an emergency condition or at the end of a routine day behind a desk. A rancher may ask it of himself at marketing time as he



recalls many trying days through the year.

It seems appropriate for me to express my thoughts to the members of the Society on a question of this kind. The human animal is an interesting beast. Regardless of where he is or what he does, he is uncertain of himself. He seeks assurance. He needs a measure of fulfillment. The psychic forces which make him different from other animals must be satisfied.

Range management (in its broadest meaning) is a worthwhile profession for many of us. It has been an opportunity for service in the interest of people, individually and collectively, with a major land resource. We operate in a historical, political, and social framework which mirrors the experience of people from the time of the westward movement to the present day.

We are part of a new and growing profession with a unique origin on the frontier of modern land management in the plains and mountains of the West and in the Southern timberlands. It is a land-oriented profession. Figuratively, we have our feet and hands on the ground and our heads and eyes to the horizon. One billion acres of land in the United States and millions of acres elsewhere are our concern and demand our attention. It is one of the most diverse of our natural resources to contend with. It is important to people as a source of water, animal products and recreation. The public demand on this resource is at an all-time high. It has direct economic as well as social value. The variety in our day-today activity is considerable and should excite our interest and challenge our ability.

Scientific range management is an integral part of the conservation movement. While other voices are raising questions about our land and its use, no professional field is more involved in environmental science. We are and have been engaged in the day-to-day job of good resource management and all that it implies. We as a profession see more clearly the need and the methods to come to terms with nature. The very success and permanence of the range livestock business, the production of quality water and wildlife, depends on a realistic understanding of nature. Of necessity we need to use modern science and technology to rehabilitate some lands and return them to their former productivity. Our science and philosophy of land management have strong naturalistic roots. We take some satisfaction from the realization that such is our understanding the resource as nature.

A sense of accomplishment is an important product of one's effort and gives not only satisfaction but justification for the professional choice. When one looks close to home or expects to find change in a short period of time, it may, in some cases, be disappointing. When one travels through miles of sagebrush or mesquite-covered lands or sees an extensive grassland producing below potential, one may wonder how long does it take to sell range management. One should also ask how can we ever manipulate the vegetation on the scale it exists or reverse a trend which has been going on for many years.

Much has been accomplished. The use of fertilizers on California annual ranges has had a significant effect on the yield and quality of feed. The practice is definitely beyond the experimental stage. Sagebrush lands in southern Idaho and northern Nevada are now producing from 10 to 20 times more forage than a few years ago. We even hear of surplus grass. Mesquite control is now being done more effectively on thousands of acres in the Southwest. We are learning to use fire as a tool for cover modification for water yield and forage production on areas in Arizona and California. There are now available supplies of native and introduced grasses for general and specialized revegetation of lands. Species adaptability can be closely specified for many seeding projects. Systems of grazing including rest-rotation, deferred-rotation as well as deferred grazing are being applied extensively. Results are such that stocking rate trends are being reversed. Newer materials and equipment are being used for water supply development and fencing. Quality ranges in the Great Plains and in many mountain valleys attest to the fact that ranges are getting better. Of special importance is that training, education, communication and general extension of knowledge about range has increased considerably in the last 20 years.

The western range country is still beautiful to the eye whether it is the rolling grasslands of the plains, the basins and ranges of the intermountain country or the high mountain valleys and parks which are being viewed. Cattle, sheep, wildlife; cloud or sky; mesas, mountain slopes or peaks —this is nature, wild but being lived with and used to meet many needs.

A profession can also be measured by the intellectual challenge which its practice may demand. The range resource is not only complex in terms of species, community types, soils, climate variability, animal behavior and response, and biological interrelationships but in the economic and social aspects of its use. We are still in the process of quantifying our knowledge of the resource and its behavior. Sound management practices which are flexible and adaptive to local conditions require problem solving at a high level using the best intellectual tools available. There are few easy formulas to solutions of many biological, economic and social problems of range management. The resource and its use requires the attention of the best minds. Intellectual ability has not been wanting. It has faced some real and original problems.

Membership in the American Society of Range Management offers perhaps the most unique opportunity for personal satisfaction for a professionally involved individual. Attendance and participation at Society and Sectional meetings provide a means of expression in a large group of people with related interests. One can help determine and give direction to the activities of an organization which is international in scope — a real sense of dimension of his professional field can be gained by reading the Journal of Range Management.

We have a profession which is strongly identified with the western portion of the United States. This would suggest some provincialism. And yet, we are anything but that. Many of you have worked in more than one geographic portion of the West or South. Administrators, researchers and teachers are travelers. Transfers, special assignments, new jobs generally mean a different geographical setting. Some have worked overseas. We communicate with people the world over who are working with range. At times this moving is considered a liability; and yet it is a personal opportunity, a chance to innovate, to try new ideas. This helps develop an individual. Finally, we have what the best of people want and that is to serve society in a constructive way.

Perhaps the best measure of the profession can be determined from the personal values secured. Over the years it has been my good fortune to observe and sometimes share in the many expressions of personal reward. Range men have an identification with community leadership. They engage in planning and execution of many community activities. They represent the public's interest in natural resources. They help guide and develop conservation practices. They are listened to with respect and confidence. This is common on many Soil Conservation Districts. Planning and sharing costs of cooperative range improvements on National Forests and Grazing Districts involves considerable assurance of competence to the land user. The amount of technical information sought by and made available to the rancher is also considerable and suggests a reasonably high degree of acceptance of what the professional has to offer. There will always exist a degree of non-acceptance by ranchers or sportsmen. This is in the nature of people. Examples exist in many other areas. The land user knows our language; he may not want to use it. Many pleasant associations are developed out of a community of interest in the land. You, no doubt, can point to many in your own experience.

We can say that range management as a professional field has been worthwhile. We identified ourselves with it out of an interest in livestock, wildlife, plants, land, and even an association with the old West. It has not only given us an employment opportunity but a unique situation in which to serve society, to meet intellectual and physically challenging situations; to gain satisfaction from many accomplishments; to associate ourselves with a wide variety of people who have helped enrich our lives. This is more than many people can expect out of a lifetime of living.

Journal Reorganization and Page Costs

Business management of the Journal was transfered to the Executive Secretary's office effective with this issue. Hereafter, page dummy, page proofs, and reprint orders will be handled entirely in the Portland office. Items for News and Notes, With the Sections and Society Business should be sent directly to the Executive Secretary.

Authors should continue to send manuscripts for articles, Technical Notes, and Management Notes directly to the Editor in Quincy, Illinois.

Effective with the January 1967 issue, a charge of $35.00 per page will be made on each article for pages in excess of the new 4-page free limt.

Notice

The Executive Secretary will pay $1.50 for each copy of the Journal in good condition, Vol. 17, No. 1, January 1964.

20th Annual Meeting

American Society of Range Management

Seattle, Washington

February 14-17, 1967

Theme: "The Next Twenty Years"

Program and local arrangements are rounding into shape for the ASRM Annual Meeting in Seattle next February. Twelve sessions have been arranged covering all phases of range management. Field tours are being considered.

The November issue of the Journal will carry the complete program, with rules for photos and displays and plant judging contests, interview service, tours, and hotel reservations.

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